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POPULAR SERIES

ADVANCED LESSONS IN PHYSIOLOGY AND HYGIENE

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THE POPULAR SERIES

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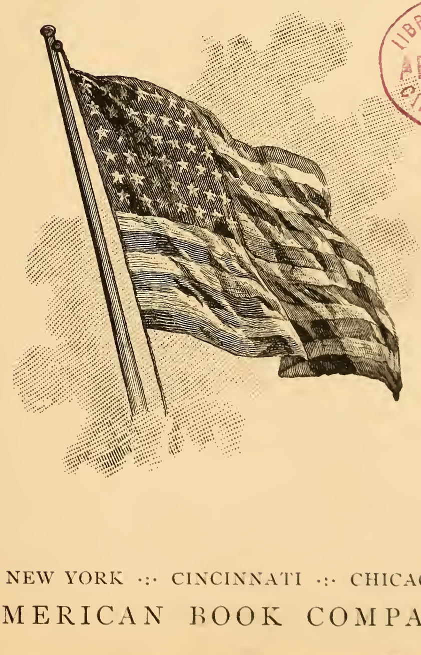
IN

PHYSIOLOGY AND HYGIENE



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PREFACE.

The physiology of the human body is, precisely speaking, an account of the uses and mutual relations of its various organs. By a looser and more convenient construction of the term, physiology has come to include some sketch of anatomy on the one side, and of hygiene on the other—the former from necessity, the latter for reasons of utility.

The object sought by the study of physiology is often asserted to be the acquisition of such a knowledge of our bodies as shall "teach us how health may be preserved;" but the object in gaining knowledge of any sort should not be narrowed to one of immediate utility. The appetite for knowledge grows with what it feeds on, and keener and more intelligent habits of observation, together with reflective study of his subject, will afford to the student many indirect compensations.

While, therefore, in this book the main treatment of the bodily organs has to do with what they are, and how they act and interact, this is followed in the several cases by an examination into the right rules underlying the maintenance of health. From the pages devoted to the hygiene of the several functions, whatever has seemed too obvious for insistence has been omitted; while, in conformity with the laws of many of the States, the evils which result from the use of alcohol, tobacco, and other narcotics are fully set forth. The views presented on this subject are in accord with the latest conclusions of science.

In the order of topics, arbitrary classification has been avoided. The interdependence of bodily functions is such that these overlap one another in many ways. The same organ may have part in different processes without completing any of them. Hence, but one arrangement has here commended itself; namely, the empirical one of treating the obvious topics in an order conforming as nearly as may be with a progression from the simple to the complex.

The author has endeavored to present in these pages a sufficient amount of material to arouse in the learner an expectant frame of mind, calling for the supplemental instruction which will suggest itself to every teacher. No space has been given to discussion of conflicting views on any subject, and nowhere is attention diverted from essentials by needless profusion of subordinate details.

Many technical terms are, of course, indispensable in the exposition of any science, but their use has been avoided in this book except so far as they have urged themselves upon the text. The etymology of these is given at the head of the chapters in which they are first used.

The chapters on "Emergencies and Accidents" and "Care of the Sick" will, if carefully studied, prove of inestimable value to the pupil. How often do we find a student who may take a high percentage on an examination in physiology utterly at a loss as to how to act in case of an accident! He may be able to give the Latin name and describe the exact location of the minutest bone in the body ; but should you suddenly meet with a severe accident, the best he can do is to leave you and seek a physician, if one be near at hand. It is not the fault of the student, however, but of the books and instructors who are willing to devote much space and time to details which are important only to physicians and scientists, to the exclusion of more useful and practical subjects.

CONTENTS.

CHAPTER I.—INTRODUCTION.

PAGE

Bodies—Non-living Bodies—Living Things—The Human Body—The Main Divisions of the Body—Organs—Membranes—Tissues—Anatomy—Physiology—Hygiene—Questions . . . 17

CHAPTER II.—THE BONES.

Skeleton—Uses of Skeleton—Number of Bones—The Bones of the Head—The Bones of the Trunk—The Bones of the Upper Extremities—The Bones of the Lower Extremities—Ingredients of Bone—General Structure of the Bones—Minute Structure of the Bones—Changes of Bony Structure—Injuries to the Bones—Bones of the Joints—Injuries to Joints—Hygiene of the Bones—Tobacco—Alcohol—Questions—Review of Bones . . 23

CHAPTER III.—THE MUSCLES.

Forms of Muscles—Classes of Muscles—Voluntary Muscles—Involuntary Muscles—Structure of the Voluntary Muscles—Tendons—The Action of the Biceps Muscle—Muscles of the Chest—Arrangement of Muscles—The Muscular Sense—Hygiene of the Muscular System—Alcoholic Drinks—Tobacco—Names of Muscles—Questions 45

CHAPTER IV.—THE SKIN.

Structure of the Skin—The Cuticle—The Nails—Hairs—The Cutis—Glands—Hygiene of the Skin—Clothing—Cleanliness—Burns and Scalds—Alcoholic Liquors—Questions 59

CHAPTER V.—FOOD.

PAGE

The Life of the Body—Mineral or Inorganic Substances—Organic Substances—Albuminoid Foods—Fats—Sugars—Diversity of Food—Cooking—Alcohol—Fermentation—Distillation—Alcohol and Food—Questions 71

CHAPTER VI.—DIGESTION.

Alimentary Canal—Mastication—Teeth—Salivary Glands—The Trunk—The Stomach—The Intestines—The Liver—Pancreas—Intestinal Absorption—The Kidneys—Questions . . . 81

CHAPTER VII.—HYGIENE OF DIGESTION.

The Manner of Eating—The Nature of the Diet—The Amount of Food—The Times of Eating—The Condition of the Mind—The Care of the Teeth—Dyspepsia—Alcohol and the Liver—Water—Alcohol—Tobacco—Opium—Poisons—Acids—Alkalies—Questions 99

CHAPTER VIII.—CIRCULATION.

General Plan of Circulation—Composition of Blood—The Corpuscles—The Plasma—The Organs of Circulation—The Heart—The Passages of the Heart—The Valves of the Heart—The Heart's Action—The Arteries—The Capillaries—The Veins—Course of the Blood—Pulmonary Circulation—Systemic Circulation—Portal Circulation—Assimilation—Removal of Waste Matter—Gains and Losses by the Blood—Lymphatics—Hygiene of the Circulation—Effects of Alcohol on the Circulation—Tobacco—Questions 111

CHAPTER IX.—RESPIRATION.

The Air—Oxygen—Nitrogen—Carbonic Acid Gas—Watery Vapor—Outline of the Breathing Process—The Organs of Respiration—The Air Passages—The Trachea—The Bronchi—The Lungs—The Diaphragm—The Intercostal Muscles—The Lungs as Organs of Excretion and Absorption—Uses of Oxygen in the Blood—Hygiene of Respiration—Ventilation—Fullness of Breathing—Positions—Alcohol—Tobacco—Questions . . 133

CHAPTER X.—THE NERVOUS SYSTEM.

PAGE

Nature of Nervous Tissue—Arrangement of Nervous Matter—Divisions of Nervous System—Cerebro-spinal Nervous System—The Brain—The Cerebrum—The Cerebellum—The Medulla Oblongata—The Spinal Cord—The Spinal Nerves—The Sympathetic Nervous System—Conscious Action—Paralysis—Reflex Action—Questions 149

CHAPTER XI.—HYGIENE OF THE NERVOUS SYSTEM.

Waste of Tissue and Energy—Exercise of Nervous System—Alcohol—Effect of Alcohol on Nervous Centers—Effect of Alcohol on the Mind—Insanity—Tobacco—Opium—Chloral Hydrate—Chloroform and Ether—Questions 167

CHAPTER XII.—THE SPECIAL SENSES.

Common Sensation—Organs of Special Sense—Touch—Acuteness of Touch—Taste—The Tongue—Tobacco—Alcohol—Smell—The Nose—Sight—The Eyes—The Lachrymal Glands—The Eyeballs—The Wall—The Retina—The Humors—Light—Hygiene of the Eyes—Hearing—The Ear—The Tympanum—Eustachian Tube—Inner Ear—Sound—Hygiene of the Ears—Questions . 175

CHAPTER XIII.—THE VOICE.

Larynx—Vocal Cords—Vibrations of the Cords—Questions . . 197

CHAPTER XIV.—VENTILATION.

Proper Ventilation of Houses—Composition of the Air—Conditions which Render the Air Impure—How to Overcome these Conditions—Draughts—Natural and Artificial Ventilation—Questions. 201

CHAPTER XV.—WATER IN RELATION TO HEALTH.

Sources of Water Supply—Water from Wells, Springs, Rivers, and Lakes—River Water—Lake Water—Impure Water—Purification of Water—Questions 211

CHAPTER XVI.—DWELLINGS.

PAGE

Site—Structural Arrangements—Removal of Waste Matter—Questions 217

CHAPTER XVII.—EMERGENCIES AND ACCIDENTS.

General Directions—Sunstroke and Exhaustion from Heat—Fractures and Dislocations—Sprains—Contusions and Bruises—Wounds—Burns and Scalds—Starvation—Choking—Hemorrhages—Fainting—Frost Bite—Apoplexy—Foreign Bodies—Venomous Bites—Poison Ivy—Intoxication—Drowning, Asphyxia, Suffocation, Strangulation—Questions 221

CHAPTER XVIII.—CARE OF THE SICK.

Nursing—The Sick-room—Ventilation—Pulse—Temperature—Respiration—The Administration of Medicine—Food—Forms of Food for the Sick—Bandaging—Poultices—Baths—Questions . 231

LIST OF ILLUSTRATIONS.

FIG. PAGE

1. Animal Cells, ... 20
2. The Human Skeleton, ... 22
3. The Bones of the Head as a Whole, ... 25
4. The Bones of the Head, Separated, ... 25
5. The Spinal Column, ... 26
6. Vertebra as seen from Right Side, ... 27
7. Vertebra as seen from Above, ... 27
8. The First and Second Vertebræ, ... 28
9. The Chest, ... 29
10. The Pelvis, ... 30
11. Right Shoulder, ... 31
12. Bones of the Right Arm, ... 32
13. Bones of the Right Hand and Wrist, ... 32
14. Right Tibia and Fibula, ... 33
15. Bones of the Left Foot and Ankle, ... 33
16. Fibula, Knotted, ... 35
17. Section of Right Femur, ... 36
18. Periosteum and Bone, ... 37
19. Cross-section of Bone—Magnified, ... 37
20. Bone Cells—Magnified, ... 37
21. Hip-joint—showing Round Ligament, ... 38
22. Hip-joint—showing Capsular Ligament, ... 38
23. Ankle and Wrist Joint, ... 40
24. Biceps Muscle, ... 46
25. Fiber of Involuntary Muscle, ... 46

FIG. PAGE
26. VOLUNTARY MUSCULAR FIBER, ... 48
27. BICEPS MUSCLE RELAXED, ... 50
28. BICEPS MUSCLE CONTRACTED, ... 50
29. THE MUSCULAR SYSTEM, ... 57
30. SECTION OF CUTICLE, ... 60
31. SECTION OF THUMB, ... 61
32 SECTION OF CUTIS AND CUTICLE, ... 62
33. PAPILLÆ OF PALM OF HAND, ... 63
34. SECTION OF SKIN OF SOLE OF FOOT, ... 64
35. MAGNIFIED SECTION OF MOLAR, ... 83
36. LOWER JAW-BONE, ... 83
37. PERMANENT TEETH, ... 84
38. PAROTID GLAND AND DUCT, ... 85
39. ESOPHAGUS—SHOWING MUSCULAR FIBERS, ... 86
40. STOMACH AND LIVER, ... 88
41. SECTION OF STOMACH, ... 89
42. ALIMENTARY CANAL, ... 91
43. VILLI, LACTEALS, AND BLOOD-VESSELS, ... 92
44. END OF LACTEAL, ... 93
45. SECTION OF PANCREAS, ... 93
46. THORACIC DUCT AND LACTEALS, ... 94
47. SECTION OF SMALL INTESTINE, ... 95
48. KIDNEYS AND THEIR VESSELS, ... 95
49. RELATIVE POSITIONS OF CHIEF ORGANS OF TRUNK, . . . 96
50. ARTERIAL CIRCULATION, ... 110
51. CORPUSCLES, ... 112
52. EXTERNAL VIEW OF THE HEART, ... 114
53. DIAGRAM OF PASSAGES OF THE HEART, ... 115
54. VALVULAR ACTION OF RIGHT SIDE OF HEART, . . . 116
55. VALVES OF THE HEART, ... 117
56. DIAGRAM OF HEART AND BLOOD-VESSELS, ... 120
57. PORTION OF ARTERY, ... 121
58. CAPILLARIES, ... 122

FIG. PAGE
59. PORTION OF VEIN, ... 123
60. DIAGRAM OF COURSE OF BLOOD, ... 124
61. LYMPHATICS OF ARM, ... 127
62. IDEAL DIAGRAM OF LUNGS AND PASSAGES, ... 136
63. CLUSTER OF AIR CELLS, ... 137
64. ORGANS OF THE CHEST, ... 138
65. INSPIRATION AND EXPIRATION, ... 139
66. CHEST BONES AND MUSCLES, ... 139
67. MAGNIFIED SECTION OF LUNG, ... 141
68. ELEMENT OF NERVOUS SYSTEM, ... 150
69. CEREBRO-SPINAL NERVOUS SYSTEM, ... 152
70. BRAIN SEEN FROM ABOVE, ... 154
71. BRAIN SEEN FROM BELOW, ... 155
72. HORIZONTAL HALF SECTION OF BRAIN, ... 156
73. RIGHT HEMISPHERE OF BRAIN, ... 157
74. SPINAL CORD, ... 159
75. PORTION OF SPINAL CORD, ... 160
76. DIAGRAM OF SYMPATHETIC NERVOUS SYSTEM. 161
77. NERVOUS CENTER, FIBERS AND GANGLION, ... 162
78. PRINCIPAL NERVES OF FINGER, ... 178
79. FINE NERVES OF TOUCH AT END OF THUMB, ... 179
80. DISTRIBUTION OF NERVES OF TASTE, ... 181
81. SECTION SHOWING RIGHT NASAL CAVITY, ... 182
82. HORIZONTAL SECTION OF EYE, ... 185
83. DIAGRAM SHOWING FORMATION OF IMAGES IN THE EYE, . . 187
84. EXPERIMENT TO SHOW BLIND SPOT OF EYE, ... 188
85. NEAR-SIGHTED EYE, ... 189
86. FAR-SIGHTED EYE, ... 189
87. DIAGRAM OF LEFT EAR, ... 191
88. COCHLEA WITHOUT NERVE. 193
89. AUDITORY NERVE OF COCHLEA. 194
90. EXTERNAL VIEW OF LEFT SIDE OF LARYNX, ... 197
91. CROSS-SECTION OF LARYNX ABOVE THE VOCAL CORDS, . . 198

FIG. PAGE
92. Board attached to Window for Ventilation, . . 204
93. Ventilation—Window Closed, ... 205
94. Ventilation—Window Open, ... 206
95. How Water is contaminated by Sewage, . . . 213
96. Rope Stretcher, ... 222
97. Stretcher formed by Four Poles, ... 222
98. Application of an Improvised Tourniquet to the Thigh, 224
99. Artificial Respiration—Inspiration, ... 228
100. Artificial Respiration—Expiration, ... 228
101. The Roller Bandage applied to the Arm, . . . 241
102. The Triangular Bandage, ... 242
103. The Triangular Bandage applied to the Head, . . 242

PHYSIOLOGY.

CHAPTER I.

INTRODUCTION.

Etymology of Terms.

ăb dō'men (Lat. *abdomen*, from *abdere*, to hide, and *omentum*, entrails).

ăd'i pōse (Lat. *adeps*, fat; *adiposus*, fat-like, fatty).

a năt'o my (Gr. *anatemnein*, to cut up).

c̶är'ti laġe (Lat. *cartilago*, gristle).

hȳ'ġi ēne (Gr. *hugeia*, health).

mĕm'brāne (Lat. *membrana*, the skin that covers the separate members of the body).

phȳs̱ i ŏl'o ġy (Gr. *phusiologia*, a talk about nature).

1. The separate things we know around us are called **bodies.** By noticing these bodies we may see that there are two kinds: (1) bodies that do not live, (2) bodies that do live. The stones, the soil, the water, the air, pieces of iron, and such things, do not live and do not grow; while the trees, the grass, the corn, the birds, and the people do live and grow.

Non-living bodies are formed and become larger by the addition of substance to the outside. **Living bodies** grow by taking food into themselves, which food they change so that, finally, it becomes a part of them. Non-living bodies are not inclined to change, but usually endure for a long time in the same condition. Living bodies originate from parent bodies ; they live and grow for a short time, and then die. No living thing can exist long as an individual. If we examine a non-living body, we shall find that all of its parts are much alike. For instance, the pieces of a stone are of the same kind, and are like the whole stone. The various parts of a living thing often differ very much. The roots of plants are not like the leaves. The bones of animals are not like the flesh.

2. The parts of living things are designed for different uses in life and growth. The roots of the plant absorb food from the soil. The leaves take food from the air and change the food till it is prepared to become a part of the plant. The bones of animals support the body, the lean flesh moves the body, the eyes aid in seeing, the ears in hearing, and other parts have other uses. The different parts of a living body which perform the many kinds of work in the body are called **organs.** Thus the heart is the organ for sending the blood through the body, the eye is the organ of sight, the lungs are the organs for breathing.

Living things are of two kinds : (1) plants, and (2) animals. **Plants** take their food from the air and soil ; they have roots for the soil, and leaves for the air and sunshine. Most **animals** must have food that has been prepared for them by plants. Thus the horses and sheep feed on grass, the bees on the sweets of flowers, and men eat grains and fruits. A plant can not feel and is fixed to the soil by roots. Animals feel, they move freely, and show by their actions that they are intelligent. The lowest kinds of animals have very little feeling, and show scarcely any intelligence ; they are much like plants. The higher animals are quick to move, acute in feeling, strong in action, and possess much intelligence. Man is the most highly developed of all animals.

Many plants move upon being touched. Many of them move as freely as do some of the lowest animals. Some plants feed, in part, at least, on animal food. The "Venus Flytrap" and the "Sun Dew" are the most remarkable of the sensitive plants. Many of the lowest animals are like plants. They are fixed to a base, and do not move from place to place. Their parts resemble leaves and flowers.

3. The human body is the only erect animal body. The average adult male Caucasian is five feet, eight and one half inches in height. The average weight is one hundred and fifty pounds; and the circumference of the chest, thirty-six inches.

The main divisions of the body are quite simple. They are:

1. the head and neck,
2. the trunk,
3. the extremities.

The head consists of two parts—the face and skull.

The trunk consists of two parts—the upper portion, called the chest, and the lower part, called the abdomen.

The extremities are known as the upper and the lower.

The body is extremely complex in the **systems of organs** that operate in it.

The chief systems of organs are:

1. the bones,
2. the muscles,
3. the digestive apparatus,
4. the circulatory system,
5. the respiratory organs, and
6. the nervous system.

The bones support, the muscles move, the digestive apparatus changes the food, the circulatory system distributes the blood, the respiratory organs perform breathing, and the nervous system enables us to feel and to control the whole body.

4. Microscopic examination shows that every portion of the body is made up of minute sack-like forms, called **cells.**

These cells are held together by various kinds of substance placed between the cells. The cells are the living, growing parts of the body.

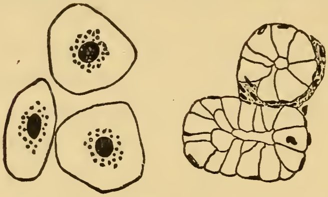


Fig. 1.

Animal Cells.

The cells are composed of an outer **membrane** and the contents of the membrane. The contents are usually fluid. The body grows by the increase in the number and size of the cells.

The cells are formed into **tissues.** Thus, we have bony tissue, in which there is lime deposited among the cells, and cartilaginous tissue, in which there is elastic matter between the cells.

The various tissues are:

1. bony tissue, which is hard,
2. muscular tissue, which has the property of contraction,
3. connective tissue, which is tough,
4. cartilaginous tissue, which is elastic,
5. adipose tissue, which is fatty,
6. nervous tissue, which is sensitive.

In the study of the human body, we should bear in mind that we are learning about our own body. We need to examine it, and to find in it illustrations of what we learn. We can feel our own bones, muscles, joints, and skin. We can feel our own heart beat. We can observe our own breathing. Our own nerves tell us what feeling is. We know what hunger is. We know what health and sickness are.

5. Anatomy tells us about the parts of the body—their appearance, structure, and situation.

Physiology tells us of the functions and mutual relations of the organs of the body.

Hygiene teaches us how to maintain the health of the body.

QUESTIONS.—1. What name is common to all the things that are round about us? By what difference of character are all bodies separated into two classes? Most animals move freely; plants and stones do not—why?

2. What are bodily organs? Has a plant organs? Do all things that live and grow, feel and think? Whence do plants get their food?

3. What can you say of the size of the human body? What are its main divisions? Of what two parts does the head consist? The trunk? What are the extremities? Name the principal systems of organs in the human body.

4. As seen through the microscope what are the minutest parts of the body? Describe a cell. Of what are our tissues composed? What tissues are the hardest? What tissues are contractile? Elastic? Sensitive? What is adipose tissue?

5. Name the science that teaches what the parts of our bodies are. The science that teaches what the parts of our bodies do. What is hygiene?

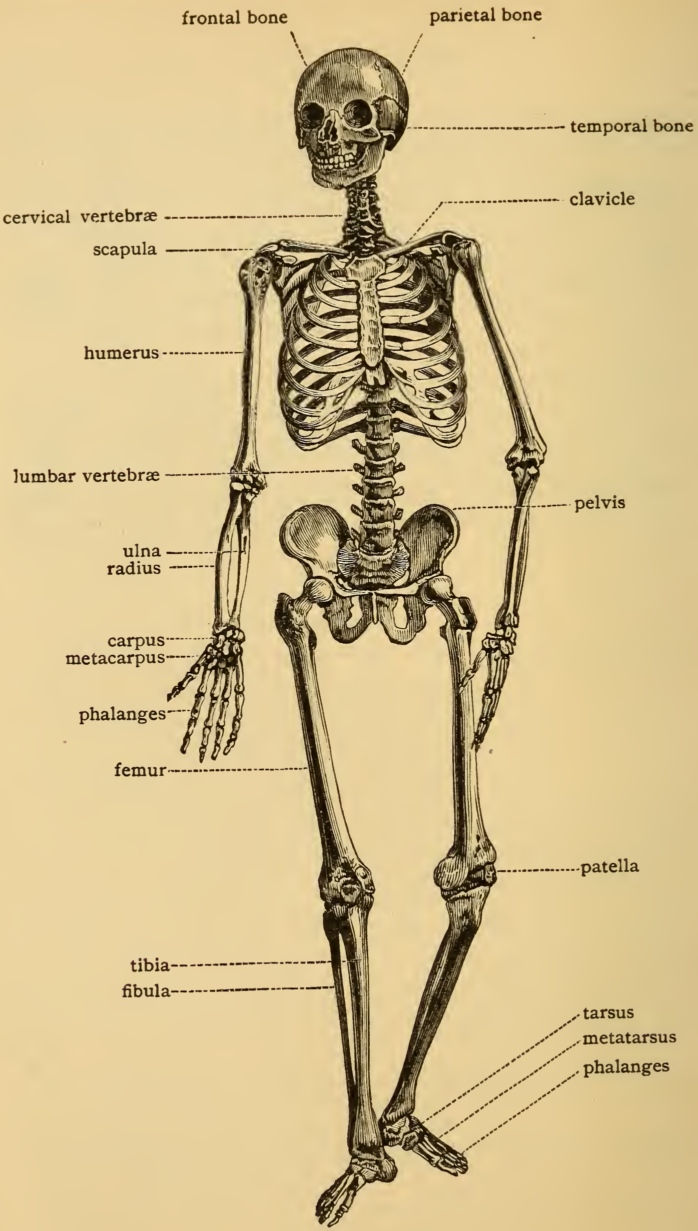


Fig. 2.

THE HUMAN SKELETON.

CHAPTER II.

THE BONES.

Etymology of Terms.

clăv'i cle (Lat. *clavicula*, a little key).
côr'pus çles (Lat. *corpusculum*, a little body).
dôr'sal (Lat. *dorsum*, the back).
fĭb'ū lȧ (Lat. a fastener).
lŭm'bar (Lat. *lumbus*, a loin).
met a cär'pus (Gr. *meta*, beyond; *karpos*, the wrist).
met a tär'sus (Gr. *meta*, beyond; *tarsos*, the tarsus).
mā'lar (Lat. *mala*, the cheek).
oc çĭp'i tal (Lat. *ob*, back of; *caput*, head).
o dŏn'toid (Gr. *odous*, tooth; *eidos*, shape).
pa rī'e tal (Lat. *paries*, a wall).
pa tĕl'la (Lat. a little pan).
pha lăn'ġēs̜ (Lat. soldiers in ranks).
pĕr i ŏs'te um (Gr. *peri*, around; *osteon*, a bone).
sū'tūre (Lat. *sutura*, stitch).
syn ō'vi al (Gr. *sun*, with; Lat. *ovum*, an egg), like white of eggs.
tĕm'po ral (Lat. *tempora*, the temples).
vêr'te brȧ (Lat. from *vertere*, to turn).

1. By pressing on the arm, we find that the outer parts are soft, and the deeper portions hard. These hard portions are the **bones.** They form the strong frame-work of our bodies, and together are known as the **skeleton.** The skeleton forms about one seventh of the weight of the body.

There are two plans of skeleton among animals: (1) In the higher animals, the frame-work is internal, with the muscles arranged about it, the whole covered with a pliable skin, as illustrated in all vertebrate or backboned animals, such as mammals, birds, reptiles, and fishes. Their skeletons are much like the human skeleton. (2) The animals that are classed next below the vertebrates have the skeleton, or hard frame-work of the body, on the outside. Such is the case with insects, crabs, lobsters, etc. In these cases, the skeleton may be likened to a hardened skin ; the muscles that move it are within.

The principal uses of the skeleton are these: (1) it gives general shape and permanency of form to the body ; (2) by the aid of the fleshy portions that are attached to the bones, the skeleton supports the body in any desired position ; (3) by the aid of the skeleton the muscles move and extend the limbs, as in walking and in reaching out the arms ; (4) the skeleton protects many of the more delicate organs by furnishing bony cavities for their safe lodgment. For instance, the unyielding skull shields the brain, its frontal projections protect the eyes, and the cage formed by the ribs incloses the lungs and heart.

2. The number of bones that unite to form the skeleton varies a little between infancy and age ; in the adult body, anatomists usually recognize 206, besides the **teeth.**

The teeth are not generally included among the bones of the skeleton. They resemble bone in structure and composition. They resist decay so perfectly that they are usually the last portions of the body to decompose. The teeth are treated of under the organs of digestion.

The bones are divided into four great groups :

1. the bones of the **head,**
2. the bones of the **trunk,**
3. the bones of the **upper extremities,**
4. the bones of the **lower extremities.**

3. The bones of the head are divided into (1) the bones of the *skull* and (2) the bones of the *face.*

The bones of the **skull** are eight in number. The largest of these are : the *frontal* bone, situated above the eyes ; the two *parietal* bones, situated in the upper part of the skull, at the back ; the two *temporal* bones, situated below these, at the temples ; and the *occipital* bone at the base of the skull. (See Fig. 4.) These bones are broad and curved, so that when joined at their edges they form the walls of an oval cavity. This cavity contains the brain. Through an opening in the base of this cavity the spinal cord passes out. The edges of these bones interlock in irregular, toothed seams called *sutures*, which hold the bones firmly together. The oval shape of the whole admirably fits the skull to resist pressure from without. A thin packing of cartilage is placed in the sutures. This cartilage has two uses: (1) it permits very slight motion in the suture; (2) it renders the shock from blows less severe to the brain, and the skull less liable to fracture. Only one of the bones of the head is movable at will, namely, the lower jaw; although the head as a whole moves freely on the topmost bones of the spine.

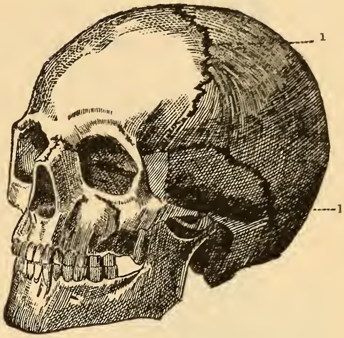


Fig. 3.

The Bones of the Head as a Whole, showing Sutures.

1, sutures.

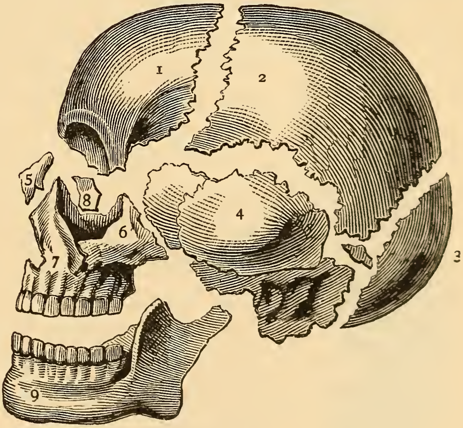


Fig. 4.

The Bones of the Head, separated to show the Principal Bones of the Skull.

1, frontal; 2, parietal; 3, occipital; 4, temporal. The principal bones of the face: 5, nasal; 6, malar; 7, upper jaw; 8, lachrymal; 9, lower jaw.

The skull bones are formed of double plates, an outer and an inner, between which there is a packing of spongy bone. This arrangement gives them great strength in the resistance of fracture by blows. In many cases the skull has been known to turn aside a pistol or rifle bullet. In infancy, the sutures are large; in middle age, they are narrow, but distinct; in old age, they nearly disappear by the growth of bone.

There are fourteen bones of the **face.** The chief of these are: the bones of the *jaws*, and the *nasal*, *malar*, and *lachrymal* bones. (See Fig. 4.) These bones are firmly fastened upon the front and lower portions of the skull. They are rigidly united with one another, excepting the lower jaw, which is free to move in opening and closing the mouth. These bones are extremely irregular in shape. They form the bridge of the nose, the prominence of the cheeks, the roof of the mouth, the jaws, and parts of the sockets of the eyes.

There is a bone, situated just under the lower jaw and at the base of the tongue, called the *hyoid* (Gr. U-shaped) bone, that aids in moving the throat in swallowing and in speaking.

4. The bones of the trunk are divided into: (1) the bones of the *spinal column;* (2) the bones of the *chest;* (3) the bones of the *pelvis.*

The spinal column, or backbone, extends from the head along the back, and supports the upper part of the body on the pelvis. This column is formed of twenty-four pieces, called vertebræ. The lowest

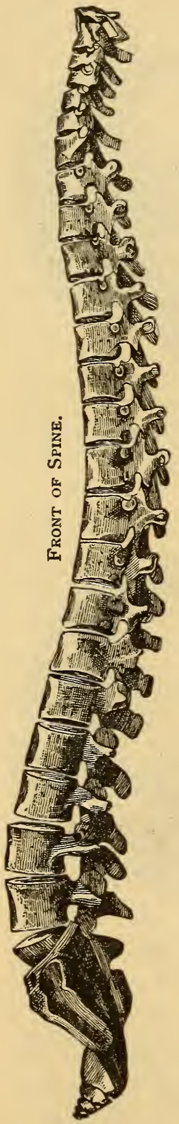


Fig. 5.
The Spinal Column.

of these twenty-four bones rests firmly on one of the bones of the pelvis. The vertebræ are placed one upon another —five in the loins, twelve in the back, and seven in the neck—with layers of cartilage between. This cartilage, although firmly fastened to the bones above and below, is elastic, and allows each vertebra to move a little. The pads of cartilage between the vertebræ vary in thickness from one fourth to one half of an inch. These pads make the spinal column elastic, so that the brain rests upon it without jar or shock. The layers diminish in thickness by pressure, so that the column may bend from side to side, or forward and backward. The pressure of the weight of the body during the day makes the pads thin, and the column as a whole shorter than it is after they have expanded during the night. For this reason, we are slightly taller in the early morning than at evening. In Fig. 5, the spaces at the left between the vertebræ are those occupied by the layers of cartilage. The combined motion of the vertebræ enables the spinal column to bend readily in any direction. The column is exceedingly strong. Through each vertebra there is an opening as shown in Fig. 7. The series of openings, one above another, in perfect adjustment, form what is called the spinal canal. Through this canal passes the spinal cord, which, with the brain, constitutes the most important part of the nervous system.

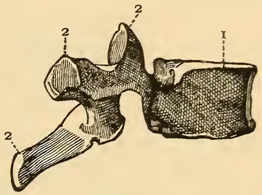


Fig. 6.

VERTEBRA, AS SEEN FROM THE RIGHT SIDE.

1, body of vertebra ; 2, processes.

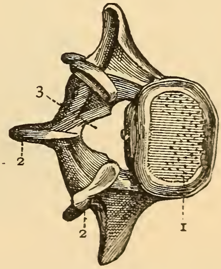


Fig. 7.

VERTEBRA, AS SEEN FROM ABOVE.

1, body of vertebra ; 2, processes ; 3, opening for spinal cord.

In each of the bones of the spinal column what is called the "body" of the vertebra (see Figs. 6 and 7) is situated toward the front of our bodies. It is upon this part of each bone that the pressure of the column is sustained. On the sides and back portion, there are many irregular projections, called processes, by which the vertebra attaches to the various parts that surround it. These processes resemble in form the thorns or spines of certain plants; hence the name "spinal column." At the sides of the spine, and throughout its whole length, are openings through which nerves branch out from the spinal cord to all parts of the body.

In describing the bones of the skull, it was pointed out that the head moves freely upon the upper bones of the spine. The adaptation of parts so as to permit the several motions of the head is admirable.

On each side of the opening through which the spinal cord passes into the skull, there is a slight downward, bony projection. These two projections fit into and rest upon corresponding slight depressions in the first vertebra. By this arrangement the head is free to *rock* in any direction.

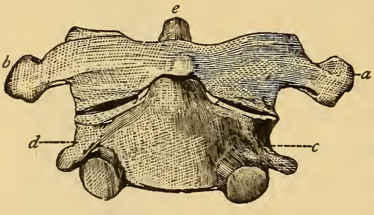


Fig. 8.

The First and Second Vertebræ.

ab, the atlas vertebra; *cd*, the axis vertebra; *e*, upper extremity of the odontoid process of the axis vertebra.

A part of the second vertebra projects upward in a bony point, called the odontoid process. This process passes entirely through an opening in the first vertebra, which is above it. By this arrangement the head *turns* freely from side to side. (See Fig. 8.)

The first vertebra, the one on which the skull rests, is called the *atlas*. Atlas was that one of the fancied deities of the ancients who was imagined to uphold the heavens. The second vertebra, the one on which the first vertebra turns, is known as the *axis*.

The spinal column curves forward in the neck, backward in the dorsal region, forward in the lumbar portion, and backward at the pelvis. By reason of these curves the spine yields to jars and sustains weights, as it could not do if it were perfectly straight. Frequently the curve in the dorsal region is greatly increased by sitting and standing in a stooped position. This deformity tends to injure the chest also. The column in its proper form bends neither to the right nor to the left. Frequently curvature to one side occurs because of weakness, or from bad position in sitting, standing, or lying.

5. The bones of the chest form a conical, bony cage. They are: (1) the *sternum* or breastbone in front, (2) the *ribs* at the side, together with a portion of the spinal column at the back.

The *sternum* is a flat bone, to which the cartilages of the ribs are fastened in front. In a child the sternum is composed of three parts, but in later life these parts join firmly into one bone, shaped somewhat like a dagger, handle upward.

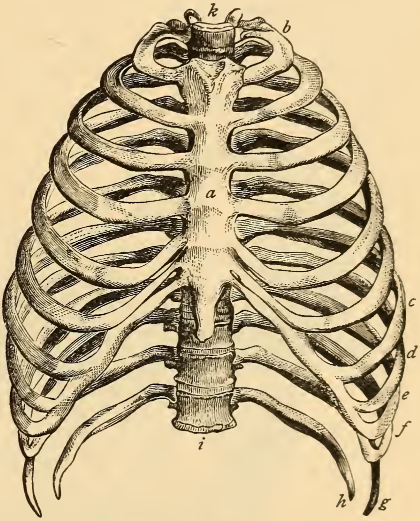


Fig. 9.

The Chest.

a, sternum ; *b* to *c*, true ribs ; *d*, *e*, *f*, false ribs ; *g*, *h*, floating ribs ; *i*, *k*, dorsal vertebræ.

The *ribs* are twenty-four in number, arranged in pairs, twelve on each side. They are long, flat, and narrow, and are curved like hoops to form the walls of the chest. They are all fastened securely, but in such a way as to permit some movement to the vertebræ behind. On each side, in front, the seven upper ribs, called the true ribs, are joined by cartilages to the sternum. The next three are united by cartilages to the true ribs, and are called false ribs. The lowest two have no front attachment, and are known as floating ribs. Accordingly, the chest is more yielding in its lower portion than in the upper. From their points of attachment to the spine the ribs curve downward toward the front of the body. They are, moreover, so connected with one another that in the movements of the chest they all act together. Our chests are, therefore, raised a little, as well as expanded, whenever we take a full breath.

6. The pelvis is composed of large bones, that form a stout, basin-like frame. (Lat. *pelvis*, a basin.) This frame bears the weight of the parts above, and supports the trunk upon the lower extremities.

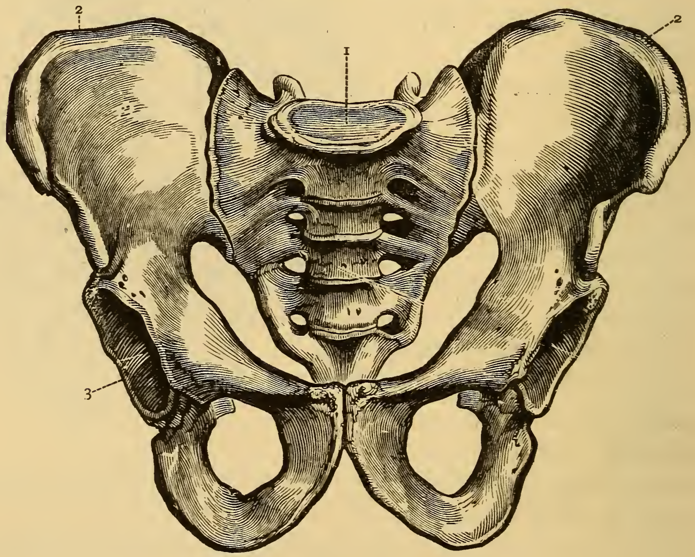


Fig. 10.

THE PELVIS.

1, sacrum ; 2, hip-bones ; 3, socket of hip-joint.

The principal bones of the pelvis are the two *hip-bones* and the *sacrum.*

The *hip-bones* have larger surfaces than any of the other bones. They are strongly arched and wide-spreading, having a rough resemblance to the opened shell of an oyster. In the sides of the hip-bones are two cup-like cavities, called sockets, into which the round heads of the thigh-bones fit, making the largest joints in the human body. (See Fig. 10.)

The *sacrum* is a triangular bone, tightly wedged downward between the hip-bones at the back. Upon the sacrum the weight of the spinal column directly rests. This bone is really a continuation of the vertebral pile, though differing from it in two respects. It is immovable, and although in the young body it consists of several separate bones, these are in adult life grown together into one. In childhood the large hip-bones, too, consist of several parts that in the full-grown body are united. This separation of parts in early life, which occurs not only with the pelvic but with other bones, permits of the spreading of the bones themselves to correspond with the increasing size of the softer tissues during the term of the body's growth.

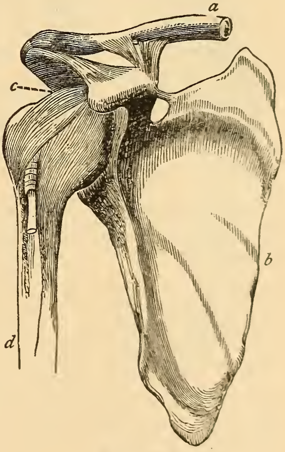


Fig. 11.

RIGHT SHOULDER, AS SEEN FROM THE FRONT.

a, clavicle; *b*, scapula; *c*, shoulder-joint; *d*, humerus.

7. The bones of the upper extremities consist, in their order, of those of (1) the *shoulder*, (2) the *arm*, (3) the *fore-arm*, and (4) the *hand.* The **clavicle**, or collar-bone, which is an *f*-shaped bone about as thick as a finger, is braced against the sternum in front; and the *scapula*, or shoulder-blade, a three-cornered bone, is fastened to the back of the chest by powerful muscles. These two bones unite to form the prominence of the shoulder and a shallow socket in which the head of the long arm bone is held. This makes the shoulder-joint. (See Fig. 11.)

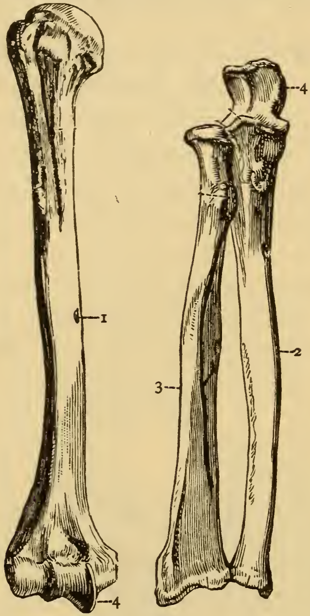


Fig. 12.

Bones of the Right Arm.

1, **humerus** ; 2, **ulna** ; 3, **radius** ; 4, **elbow joint.**

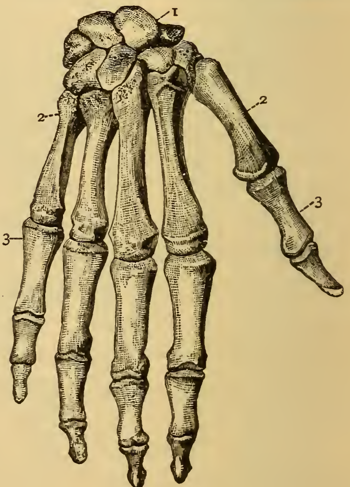


Fig 13.

Bones of the Right Hand and Wrist, Palm Down.

1, **carpal** ; 2, **metacarpal** ; 3, **phalanges.**

The long bone of the arm is called the *humerus.* Its length is about a foot. The *ulna*, the inner bone of the fore-arm, joins with the humerus to form the elbow. This is a hinge-joint, the head of the radius being fitted into a ring or collar on the side of the ulna. A companion bone, the *radius*, is placed by the side of the ulna in the fore-arm. These two bones twist about each other in turning the hand over. The radius joins the hand on the thumb side. When the hand lies with the palm upwards, the radius is on the outer side. In turning the hand over, the ulna remains fixed and the radius turns over it. By grasping the fore-arm with the hand, one may feel the motion of the radius as it turns. (See Fig. 12.)

At each wrist there are eight pebble-shaped *carpal bones*, bound firmly together by cartilage and muscle, but so as to give great freedom of motion to the hand. Here the ulna fits into a collar on the side of the radius. The five *metacarpal bones* form the palm of the hand, and the fourteen *phalanges* form the fingers and thumb. (See Fig. 13.)

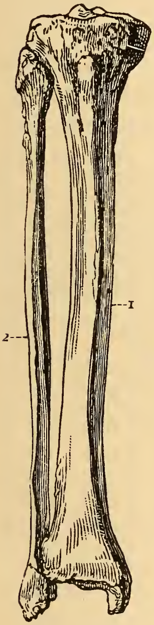


Fig. 14.

Right Tibia and Fibula.

1, tibia ; 2, fibula.

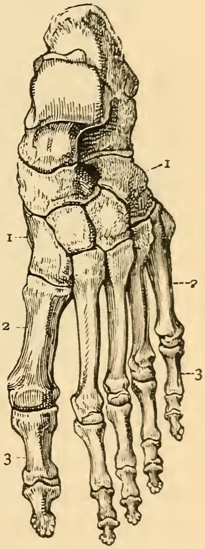


Fig. 15.

Bones of the Left Foot and Ankle, Upper Surface.

1, tarsal; 2, metatarsal ; 3, phalanges.

8. The bones of the lower extremities are those of the thigh, leg, and foot. They are connected with the sides of the pelvis by the insertion of the head of the *femur*, or thigh-bone, in a deep socket of the pelvis. (See Fig. 16.) This forms the hip-joint. The femur is the longest bone of the body. It joins at the knee with the *tibia*, or shin-bone, of the leg. A small, oval bone, called the *patella*, or knee-pan, fits into the knee-joint in front, and serves as a sort of pulley for the muscles and tendons above and below it. The *tibia* and *fibula* are placed side by side in the leg. (See Fig. 14.) At each ankle these two unite with the seven *tarsal bones* to form the ankle-joint. The tibia makes the inner, and the fibula makes the outer ankle projection. The *tarsal* and five *metatarsal bones* make the arch of the instep, and the fourteen *phalanges* form the toes. (See Fig. 15.)

At the end of this chapter will be found a table of the bones of the body, and a diagram of the skeleton as a whole is given on page 22. From these it may plainly be seen that there is a close resemblance between the upper and the lower extremities in both the number and the arrangement of their bones. The arm, fore-arm, wrist, and hand correspond respectively with the thigh, leg, ankle, and foot.

The larger bones of both extremities are those nearest to the trunk ; the double bones of the fore-arm correspond with the double bones of the leg. At the shoulder and the hip there are joints of one kind ; at the elbow and the knee there are joints of another kind. The hand is of more delicate structure than the foot, having a higher order of work to perform. It is far more prehensile—that is, fitted to grasp—owing to the arrangement by which the thumb can be opposed to each of the fingers, as well as to the length and flexibility of the fingers themselves. The foot is the bearer of the body's weight, and the fulcrum of its locomotion. Accordingly, the arch of the instep gives to it great strength and elasticity.

The intricate mechanism by means of which the hands and wrists and the feet and ankles are adapted to their great variety of movements is indicated by the fact that in these parts are situated more than half the bones of the body.

9. Ingredients of Bone.—The bones are composed of two kinds of matter : (1) a jelly-like substance, which is the animal matter, and (2) a hard substance, which is the mineral part. The bones of very young persons contain much animal matter, and the bones of adults consist of about twice as much mineral as animal substance. Hence, the bones of young children, although they may be deformed by pressure or by bad position, are not easily broken. It is by the combination of these two kinds of matter that the bones possess their great strength. The mineral part, which is mostly phosphate of lime, makes them hard and firm ; and the animal portion, which is cartilaginous, preserves their toughness and elasticity. By burning a bone, the animal part is driven off by the heat, and the limy portion is left in the form of a white, brittle body, resembling chalk. By placing a fresh bone in weak acid for a few hours, the mineral part will be dissolved, and the cartilage will remain. This will have the shape and size of the original bone, but will be so soft that it may be tied in a knot. (See Fig. 16.)

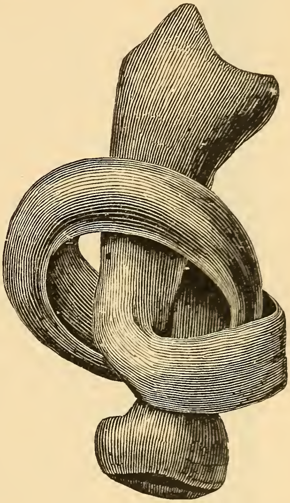


Fig. 16.

Fibula, freed of its Mineral Part and knotted.

It is the animal part of bones that is used in the making of soups and jellies. This portion is extracted by boiling. Glue is made from the animal portion taken from the feet of slaughtered animals. The mineral part of bones is used in making fertilizers. In some regions of the world, immense beds of fossil bones and other animal remains are productive of valuable articles for enriching the soil. Phosphorus, which was formerly much used in the manufacture of matches, is obtained by the chemist from the burned bones of animals.

10. General Structure of the Bones.—Our bones vary in form according to position and use. Some are long, for leverage, such as the larger bones of the extremities. Some are flat, for protection and strength, like the shoulder-blade and the plates of the skull. Some are irregular, to suit other uses. Such are the vertebræ and the bones of the wrist. The long bones are hollow and are thus large and strong without being heavy. A solid cylinder is not so strong as a hollow one made of the same amount of the same substance. The outer part of the femur, for example, is a dense, hard shell, but toward the center the matter becomes more porous, and the hollow middle is filled with a fatty substance, called marrow. The ends are large, to render the joints strong. The outer shell of the ends is thin, and the whole inner portion is composed of numerous tiny cavities, separated by thin, bony partitions. These cavities are filled with fluid, and the ends are, therefore, not so heavy as if they were solid bone. Between the ends, the outer shell of the bone is much thicker, so that these slenderer parts also may be strong. (See Fig. 17.) The bones have considerable elasticity. This is best seen in long and slender ones like those of the ribs.

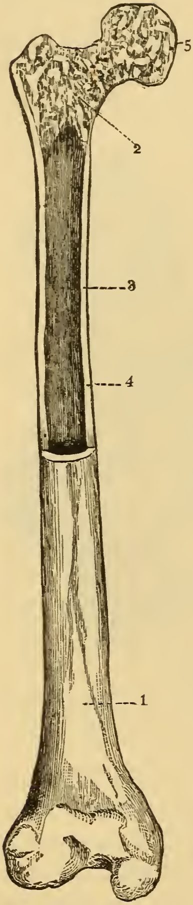


Fig. 17.

Partial Section of Right Femur, Front View.

1, external view; 2, cellular portion at end; 3, hollow in middle; 4, thick shell of middle; 5, head of femur.

Living bones are covered with a tough, yellowish-white membrane, called the *periosteum.* This membrane, which holds so tightly to the bones as almost to seem part of them, protects and nourishes them. (See Fig. 18.)

This tough cover, together with the many prominences and roughnesses on the bones, affords attachment to the soft parts (muscles) that move the bones. At the ends of bones, where the hard surfaces meet in the joints, cartilage takes the place of periosteum.

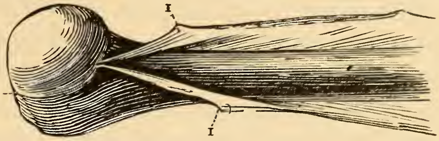


Fig. 18.

PERIOSTEUM AND BONE.

1, periosteum, cut apart from humerus; 2, termination of periosteum at joint.

11. Minute Structure of the Bones.—The bones are filled with myriads of tiny passages and cells. The largest of the passages, or canals, as they are called, carry nourishing portions of the blood to the various regions of the bone, and most of them run lengthwise of the bone. Much smaller canals are arranged round about the larger ones, some in straight lines, and some in irregular circles. These smaller canals are connected with minute cavities, and these, in turn, contain corpuscles, or tiny cells, which supply the pores of the bone with material for growth and repair. Running out in every direction from the cells are ray-like offshoots, by means of which the whole substance of the bone is nourished.

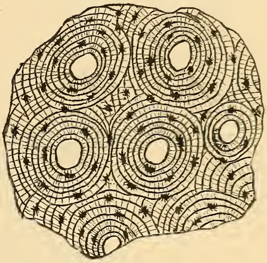


Fig. 19.

CROSS-SECTION OF BONE, MAGNIFIED.

The six openings represent large canals; the fine lines are smaller passages; the black spots are bone cells.

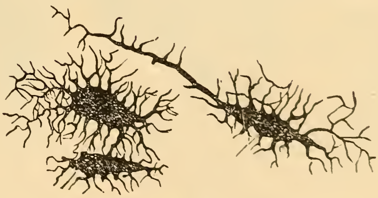


Fig. 20.

BONE CELLS, MAGNIFIED, SHOWING RAYS.

Changes of Bony Structure. — The young bones are soft, and are composed in some cases of cartilage and in others of fibrous tissue. These soft bones have the proper shape and size. They become hardened by the deposit of mineral matter within them until they are rigid bones. During life, the bones, like all other parts, are constantly undergoing change of structure. The old material is being removed, and new matter is taking its place. These changes are effected by means of the *periosteum*, which aids in the growth of the bones, and in their nourishment, through life. From the periosteum the nutrition passes into the bones through small tubular openings in their surfaces.

12. Injuries to the Bones.—A broken bone is repaired in the same manner in which the bone grows. At first, a watery fluid is poured out about the broken ends; this fluid thickens day by day, until it is jelly-like and fibrous in composition. This matter hardens by the deposit of mineral matter, so that in about six weeks the broken parts are reunited. The union is frail, however, for several months. Finally the place of fracture becomes firm, and is even stronger, in some cases, than are the other parts of the bone.

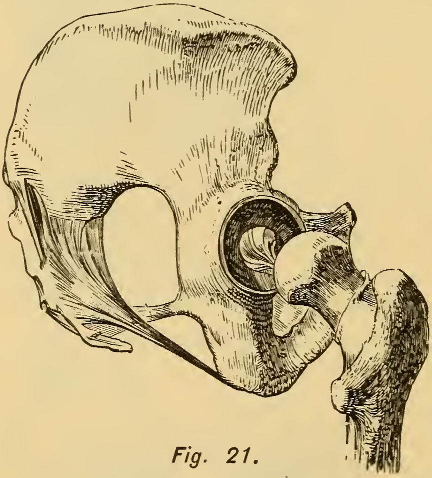


Fig. 21.

Hip-joint, Capsular Ligament cut away, and showing Round Ligament that holds the Ball in the Socket.

In cases in which bones are broken, place the sufferer in the most comfortable position possible, and the broken part as nearly as may be in the natural shape, keeping the parts from moving. Call a competent surgeon at once. If no physician can be obtained, place the broken bones in their natural position by gently but firmly stretching and pressing the parts. Bind, not too tightly, with such a bandage as will prevent change in the position, until the broken bones are firmly united. (See p. 223.)

13. Joints.—The junction of two or more bones is a *joint.*

The skeleton is separated by joints into many parts. Without this provision, both growth and motion would be impossible. A joint may be formed for the purpose of binding the bones together immovably, as in the case of the sutures of the skull ; or a joint may be designed for the free movement of the parts, as with the joints of the fingers. Such unions as the latter are called movable joints. Movable joints are classified into : (1) *hinge-joints*, such as those of the jaws, elbows, and knees ; (2) *ball-and-socket joints*, as in the case of the shoulder and hip joints ; (3) *compound joints*, like the wrists ; and (4) *pivot-joints*, such as the rotation of the radius about the ulna, in the fore-arm.

In movable joints the ends of the bones do not touch each other, but are covered with a layer of *cartilage*, which prevents the jar and wear that would occur if the ends of the bones should rub together. The cartilage on each bone is covered with an exceedingly smooth membrane, called the *synovial membrane.* This membrane lines the whole inner surface of the joint. It secretes an oily fluid between the surfaces that rub together, so that the joint moves with the greatest possible ease and smoothness.

The great strength of a joint is due to the enlarged ends of the bones, and to the bands or *ligaments* that bind the bones together. These ligaments are formed of dense, white, inelastic, fibrous tissue. The largest of these are fastened from bone to bone, over the joint, so as to inclose the two ends of bone in one band or capsule. (See

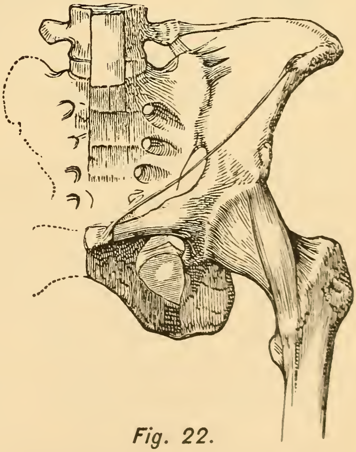


Fig. 22.

Hip-joint, showing Capsular Ligament.

Fig. 22.) Besides this kind of ligament that surrounds the joint, and which is called the *capsular ligament*, other short ligaments, within the joint, fasten the ends of bone together. (See Fig. 21.) The joints are so strong that, in cases of fracture, the bones of the extremities will usually break elsewhere than at the joints. Still another sort of ligament, called *annular*, or ring-shaped, is that which binds together the tendons at the wrist and ankle joints. These ligaments give great firmness to parts that specially need support, enabling them to withstand the strain to which they are constantly subjected, and protecting them against sprains and dislocations. The four annular ligaments are of the firmest texture, and somewhat resemble bracelets. (See Fig. 23.)

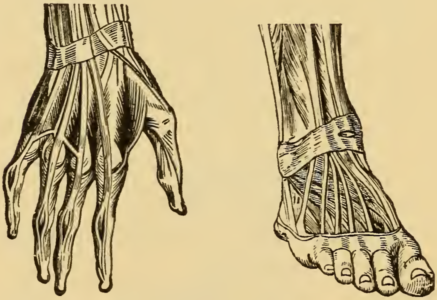


Fig. 23.

Ankle and Wrist Joints, showing Annular Ligaments.

The bones of the joints are held together in part by the fitting of the ends of the bones to one another, in part by ligaments, and in part by atmospheric pressure. Especially is this true of the ball-and-socket joints. It is estimated that the head of the femur is held in the socket of the pelvis by a pressure of the air equal to eighteen pounds, a force sufficient to bear the weight of the whole lower extremity.

Injuries to the Joints.—The joints are often injured by violent twist or pressure. If the joint is so violently bent as to tear or damage its ligaments, the injury is called a *sprain*. A sprain produces great pain, and often requires a long time for recovery. The ligaments are slow to mend. The joint is usually weak for a long time afterward.

When one end of a bone slips from its proper place in the joint it is said to be dislocated, or "out of joint." Such an injury is most likely to occur to the round head of the humerus, in the shallow socket of the shoulder. To return the bone to its place requires skillful stretching of the joint and pressure upon the dislocated bone. *Dislocation* weakens a joint, so that the same misfortune is likely to recur with a joint once injured in this manner. (See p. 223.)

14. The hygiene of the bones is affected by *food.* If children are fed on diet that is deficient in bone-making substances, the bones do not become rigid and firm. The bones of children are softer and more flexible than those of grown persons, and are injuriously affected by anything that prevents proper nutrition during this period of growth.

Exercise strengthens the bones by causing more blood to flow to them, and by forming the necessary deposit of matter in them for their growth. Yet exercise must not be carried to severe extremes. The skeleton does not become thoroughly knit until after the twentieth year, and "training" for athletic sports is attended by some risks.

Great care needs to be taken not to deform the bones in early life by pressure and improper *position.* Injury is especially liable to occur to the bones of the chest by tight dressing, and to the spinal column by sitting or standing in a stooped position. Habits and shapes acquired in this way in early years are scarcely to be remedied in later life. The bones of the foot are very generally deformed by ill-fitting shoes, and by the wearing of high heels. This fashion tends not only to misshape the feet, but also to weaken and deform the bones of the lower limbs. The gait and the whole bearing of the body become abnormal.

15. Injuries to the joints, especially dislocations, require prompt attention. If this is not given, the parts speedily become inflamed, the muscles attached to the dislocated bones increase the displacement, and this aggravates and extends the inflammation. Long neglect in such cases may result in the destruction of the synovial membrane, and in the growing together of the separated bones. Inflammation may be somewhat allayed by the application of hot water, and the bones should be quickly restored to position by a competent operator.

When children are ill-fed, they often suffer from a disease called "rickets," in part, at least, due to weakness and imperfection of the bones. In extreme cases of this kind the bones are like wax. The lower extremities of very young children are frequently bowed outward at the knees before the bones are sufficiently strong to sustain the weight of the body. The principal treatment in such cases is to improve the general health. Free exposure to pure, bracing air, and abundance of suitable food are demanded.

There are very many ways in which we may injure the body and prevent its natural development. We may stunt the growth of the body by poor food and overwork. We may also stunt its growth by the use of such injurious substances as **tobacco** and **alcoholic liquors.** These substances are such powerful poisons that there is general agreement among scientific men that the use of either is injurious to the growth of the bones.

QUESTIONS.—1. What name is given to the bones as a whole? What is meant by "vertebrate animals"? How heavy is the human skeleton as compared with the rest of the body? Name the uses of the skeleton.

2. How many bones are there in your body? Into what four great groups are these naturally divided?

3. What are the two divisions of the bones of the head? Name the chief bones of the skull, and describe their positions and uses. What are sutures? Describe the principal bones of the face.

4. What two groups of bones in the trunk? Describe the position and uses of the spinal column. What is a vertebra? The spinal canal? The odontoid process? How does the head rock and turn?

5. Name the bones of the chest. To what are the ribs attached in

front? At the back? Describe the sternum. Name the three kinds of ribs. How many of each?

6. Where is the sacrum? What important use has this bone? Describe the larger bones of the pelvis. The uses of the hip-bones. The pelvic bones undergo changes between infancy and age—how and why?

7. By means of what two bones is the arm held fast to the trunk? Describe the clavicle. The scapula. What bones meet at the elbow? Which of these is the longest? By means of what bone is the hand enabled to move in a circular line upon the elbow as a center? Describe the several movements of ulna and radius upon each other. What name is given to the wrist bones? Where are the phalanges of the hand? What bones are situated between the fingers and the wrist?

8. What is the longest bone in the body? With what bone is the femur joined at its upper extremity? With what bones at the knee? Name the bones of the leg. Which of these forms the inner projection of the ankle? What is the patella? Describe the tarsus. The metatarsus. The phalanges of the foot. How many bones in each? What can you say of the correspondence of the bones of the upper extremities with those of the lower? Of the number of bones in hands and feet?

9. Of what two kinds of substance are bones composed? What is the principal mineral substance in the bones? What is the nature of the animal part? Which of these preponderates in the bones of adults?

10. How are bones classified as to form? Describe the general structure of the femur. By what provision are the long bones strong without being heavy? Describe the periosteum.

11. As seen through the microscope, does bone look solid or porous? Describe the larger of the minute bone canals. The smaller. The bone cells. Of what use are these tiny passages and cavities? How does nourishment get into the bones from outside?

12. How does nature heal a broken bone? What course should be pursued in case of fracture of a bone?

13. What is a joint? What are the main types of joints? Describe a capsular ligament. What other important ligament strengthens the joints? Describe the annular ligaments. How does nature guard against friction in the joints? What is the difference between a sprain and a dislocation? How else than by ligaments are bones held together at the joints?

14. How is the health of bones affected by food? By exercise? By position? What bones are specially liable to be misshapen by pressure? (*Ans.*—Those of the chest, spine, and feet.)

15. Why should injuries to the joints receive prompt attention? What is the effect of narcotic poisons upon the growth of the bones?

REVIEW OF THE BONES. (See Fig. 2, page 22.)

Head.

Skull	Frontal—*front part of skull*	1	
	Occipital—*back part of skull.*	1	
	Parietal—*walls of skull*	2	
	Temporal—*temples*	2	
	Sphenoid—*base of skull*	1	
	Ethmoid—*in front of the sphenoid*	1	
	Ear Bones—*inside the ear*	6	14
Face	Nasal—*bridge of nose*	2	
	Lachrymal—*tear tubes into nose*	2	
	Vomer—*partition in nose*	1	
	Turbinated—*walls of nose*	2	
	Malar—*cheek bones*	2	
	Superior Maxillary—*upper jaw*	2	
	Inferior Maxillary—*lower jaw*	1	
	Palate—*roof of mouth*	2	
	Hyoid—*base of tongue*	1	15

Trunk.

Spine	Cervical Vertebræ—*neck*	7	
	Dorsal Vertebræ—*back of chest*	12	
	Lumbar Vertebræ—*back*	5	24
Chest	True Ribs—*upper part of chest*	14	
	False Ribs—*middle part of chest*	6	
	Floating Ribs—*lower part of chest*	4	
	Sternum—*breast-bone*	1	25
Pelvis	Sacrum—*support of column*	1	
	Innominata—*hips*	2	
	Coccyx—*below the sacrum*	1	4

Upper Extremities.

Clavicle—*collar-bone*	2	
Scapula—*shoulder-blade*	2	
Humerus—*arm*	2	
Radius—*fore-arm*	2	
Ulna—*fore-arm*	2	
Carpal—*wrist*	16	
Metacarpal—*palm*	10	
Phalanges—*fingers and thumbs*	28	64

Lower Extremities.

Femur—*thigh-bone*	2	
Patella—*knee-pan*	2	
Tibia—*shin-bone*	2	
Fibula—*brace of tibia*	2	
Tarsal—*ankle and heel*	14	
Metatarsal—*instep and ball*	10	
Phalanges—*toes*	28	60
Total		206

CHAPTER III.

THE MUSCLES.

Etymology of Terms.

bī'çeps (Lat. *bis*, twice; *caput*, head); hence, two-headed.

ꞓon trăꞓt'ĭle (Lat. *contrahere*, to draw together), shortening.

dī'a phragm (Gr., a partition).

ex tĕn'sor (Lat. *extendere*, to stretch out).

flĕx'or (Lat. *flectere*, to bend).

in ter ꞓŏs'tal (Lat. *inter*, between; *costa*, a rib).

mŭs'çle (Lat. *musculus*, a little mouse).

nū'ꞓle us (Lat. *nux*, a nut); hence, kernel; the center of any mass.

tĕn'don (from Lat. *tendere*, to stretch).

1. The parts surrounding the bones are soft. These soft, fleshy portions are the **muscles.** All the motions of the body are produced by the action of the muscles. Many of the bones and joints are nicely adapted for motion, but require the muscles to move them. The muscles are precisely like the lean meat of the ordinary slaughtered animal. They are of a deep red color. Their peculiar property is that of contraction and relaxation. By contraction they become shorter; by relaxation they are made longer. By contraction and relaxation they move the bones and other parts to which they are fastened. Muscles cover the head, enclose the organs of the trunk, and form a large proportion of the whole substance of the extremities. They give roundness of form to the body, and conceal the skeleton.

Forms of the Muscles.—The muscles have great variety of form to adapt them to their many uses. Some are cord-like, some resemble flat bands, some are ring-shaped. Some very important muscles, like the heart and stomach, for example, are hollow. Many muscles spread out like a fan, in order that their fibers may attach themselves to different parts of broad surfaces. Such are the muscles of the head and trunk. In some muscles the fibers are very much thicker at the middle of their length than they are at the ends. A good example of this sort of muscle is shown in Fig. 24.

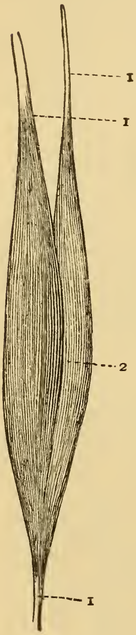


Fig. 24.

Biceps Muscle.

1, tendon; 2, muscular portion.

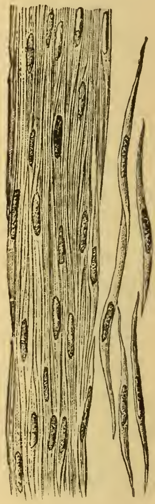


Fig. 25.

Fiber of Involuntary Muscle.

2. Classes of Muscles.—Some of our muscles act under the influence of the will. Such are the muscles of the extremities, those of the trunk which are brought into play by the movements of the extremities, and some of those of the head. All muscles of this class are called **voluntary muscles.**

Others of the muscles act without conscious impulse from the mind. Such are those of the vital organs. The heart, stomach, intestines, and the walls of the arteries are muscles of this class. These are called **involuntary muscles.**

A few of our muscles act sometimes from the conscious direction of the will, and sometimes without it. Such are the muscles which move the eyelids.

The two classes of muscles differ from each other both in their uses and in their structure. The **voluntary muscles** are chiefly concerned in the motion of the body as a whole, and of its parts, upon one another. Accordingly, most of these muscles have sinewy tissues by which, at both ends, they are attached to the bony frame-work of the body. Generally one end of each muscle is attached to one bone, and the other end to another bone; so that there is a joint of some sort between them, to be bent when the muscles act. (See Fig. 28.) These muscles, which under the control of the will move the body and its parts, act quickly. They constitute the great bulk of all muscular tissue, and, taken together, form about half the weight of the body.

The involuntary muscles are situated, for the most part, in the cavity of the trunk. They act upon every internal organ that has motion. They are not attached to the bones of the skeleton. Except in the case of the heart, the tissues of which are complex in structure, the involuntary muscles contract and relax slowly. They are busied with vital processes that are gradual, and which, if dependent upon the constant direction of the will, would not only be poorly performed, but would distract the mind and deprive the brain of rest. The action of the involuntary muscles is mainly due to irritation of the delicate membranes in which they are enclosed by the various substances which come in contact with them. Food, for example, stimulates the lining membrane of the several digestive organs. These organs must give forth their various secretions and absorb nutrition. These processes as a whole call for the action of the surrounding muscular tissues.

The involuntary muscles are made up of flat bands of long fibers. As seen under the microscope, each of these fibers has a spot called a nucleus near its center. (See Fig. 25.) The movements of involuntary muscular fibers are slow and wave-like, from each end toward the central nucleus and back again.

3. The structure of the voluntary muscles may be best studied by considering a long muscle, such as the *biceps* in the front of the arm. This muscle is a long object, as shown in Fig. 24. It has two heads by which it is made fast to the shoulder. (See Figs. 27 and 28.) The middle portion is somewhat cylindrical in form, while the ends are tapering. This middle part, which is muscular, is composed of layers and bundles of fibers that extend lengthwise of the muscle. Each bundle of a long muscle is encased in a sheath of extremely tough, elastic tissue, and the entire muscle is enclosed in a dense layer of fibrous tissue, which serves to keep the bundles in place and to give strength to the whole. At the thigh, for example, where great strength is demanded of the muscles, not only is this outer tissue very thick and strong, but there is a special muscle to draw it more tightly around the parts. (See *Tensor Femoris*, Fig. 29.)

The fibrous coats of the bundles extend to the ends of the muscle, and compose the strong, inelastic parts called tendons that attach the muscles to the bones. Each bundle of fibers is in turn made up of many smaller fibers, each of these being covered with its delicate coat of fibrous matter. These minute fibers of muscle are composed of many little muscular cells. (See Fig. 26.)

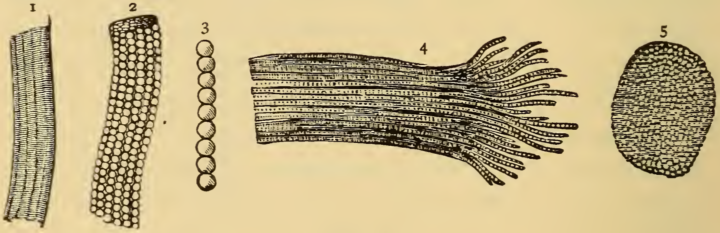


Fig. 26.

Voluntary Muscular Fiber, magnified.

1, fiber in sheath; 2, the same more highly magnified; 3, tiny muscular cells; 4, fiber cut lengthwise; 5, fiber cut crosswise.

4. Tendons.—Tendons, or sinews, are white, shining cords of fibrous tissue, very tough, strong, and inelastic.

They connect the muscles with the bones, and are generally near the ends of the muscles, and therefore near to the joints. The tendons gradually shade off in their texture, becoming muscle at one end and periosteum at the other, without any sharply defined line of separation in either case. Sometimes these tough fibers penetrate through small tubular openings into the bone itself. Where the muscular force exerted is very great, the tendons are sometimes bound down by ligaments, which prevent them from being pulled out of place. (See Fig. 23.) To obviate friction at these points, synovial fluid, such as lubricates the joints, lines the passages through which the tendons play. The largest tendon in the body is that which fastens the muscles of the calf of the leg to the heel. This is known as the tendon of Achilles.

The muscles perform many of the most important operations in the body. The muscles of the chest are engaged in respiration; the heart circulates the blood; the muscular walls of the stomach and intestines aid in reducing food; the muscles of the face move the jaws and eyes; and the muscles of the larynx control the action of the vocal cords in making the sounds of the voice.

5. The action of the biceps muscle may be felt by grasping the arm tightly while the fore-arm is extended. The cells are the part of the muscle that possesses the property of contracting and relaxing. By the influence of the nerves that lead to the muscles, each cell may be caused to shorten slightly. It is the shortening of all the cells that causes the muscle to become shorter and broader. The shortening of the muscle pulls the bone and causes motion. Now, as the muscle pulls the fore-arm up, the change in form may be felt, the muscle becoming short, full, and firm. In Fig. 27 we see that while the fore-arm is extended the biceps muscle is long and relaxed. In Fig. 28 the muscle is contracted and the fore-arm is drawn upward. The biceps muscle is attached to the scapula and the humerus at the shoulder, and to the bone of the fore-arm near the elbow (see Fig. 28), so that a slight change in the length of the muscle causes considerable movement of the fore-arm. Most of our muscles are thus arranged, so that they produce a great deal of motion by a small amount of contraction.

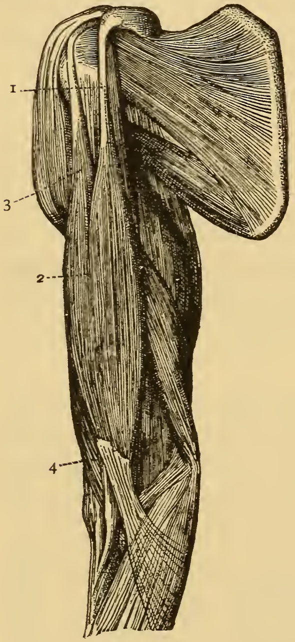


Fig. 27.

Biceps Muscle relaxed.

1, 3, two heads of the muscle; 2, muscular portion; 4, tendon fastening to the fore-arm.

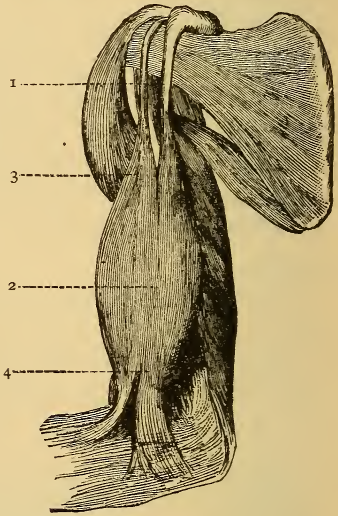


Fig. 28.

Biceps Muscle contracted to raise the Fore-arm.

1, 3, two heads fastened at the shoulder; 2, contracting portion; 4, end fastened to the fore-arm.

The muscles that close the fingers are placed on the front of the fore-arm, and those that open the hand are on the back of the fore-arm. The long, slender tendons that reach from these muscles to the fingers pass along the wrist and hand to the joints of the fingers. By grasping the fore-arm, these muscles may be felt in their motion, and, by pressure on the wrist, the tendons may be felt like so many strong cords. Why and how it is that the voluntary muscles respond to the promptings of the will, we do not know. All that we can say is that the stimulus for their motion is always conveyed to them through the nerves.

6. Muscles of the Chest.—At the end of this chapter will be found a table of the principal exterior muscles of the body, together with a diagram showing their several positions. Within the chest, however, are some of the most important muscles of the system. Among these are the muscles of the *stomach* and *heart*, organs which will be considered in later pages. The interlacing muscles of the ribs, which by their action draw these bones upward to enlarge the chest, are of great importance. They consist of two sets, one on the inner side and one on the outer side of the ribs, and are called *intercostal* muscles. The great muscle which constitutes the lower wall of the chest, separating the heart and lungs from the organs of the abdomen, is called the *diaphragm*. The intercostal muscles and the diaphragm are brought into use in the alternate expansion and contraction of the chest in breathing. Their operations will be considered in the chapter on "RESPIRATION."

7. Arrangement of Muscles.—The muscles weigh more than all the rest of the body. There are more than twice as many muscles as there are bones. They are usually placed in pairs, on opposite sides of the body, and on opposite sides of the parts they are to move. By this arrangement, when one muscle, or set of muscles, produces motion in one direction, there is an antagonistic, or opposing set of muscles ready to draw the parts back to their former position. It is by this coöperation of pairs or double sets of muscles that we are enabled to open and close the eyelids and the lips, and to make use of all of the joints of the body. Muscles that bend the joints are called *flexors*, those that straighten the joints are called *extensors*.

8. The Muscular Sense.—If we lift two different weights, we are immediately conscious that one of them is heavier than the other. We know this without help from vision, for we are just as conscious of the difference in weight when the eyes are closed. We know it without help from the special sense of touch, for the two weights might be of the same size, shape, and texture—the one solid and the other hollow. The same immediate realization of difference in weights or pressures, both from things external to ourselves and from the parts and movements of our own bodies, is afforded by all parts of the voluntary muscular system. This consciousness is called the *muscular sense.* By means of it we are able, without mental attention, to maintain an erect position in standing, and to regain our balance at every step in walking and in every kind of exercise. This sense is developed by experience, beginning with our earliest years, and is susceptible of a high degree of cultivation.

9. Hygiene of the Muscular System.—Each muscle requires intervals of *exercise* and *rest.* Relaxation is the resting, and contraction, the working stage of the muscle; hence it is that each muscle alternately contracts and relaxes. Rest and sleep must intervene between seasons of work, to restore the wasted parts and to renew the energies. During sleep, the whole muscular system becomes relaxed. The will ceases to direct the voluntary muscles, and the involuntary system is reduced in energy, as is seen in the slower action of the chest and heart. During the waking hours, all is activity and wear; during sleep, the parts are built up and refreshed.

The muscles of the chest, heart, and digestive organs gain rest during the day by performing their tasks in intervals of work, followed by corresponding rests. For instance, the time for the drawing in of the breath, which is done by muscular action, is nearly equaled by the time of breathing out the air, which admits of muscular rest. The muscles may be relieved by such change of employment as calls into action other parts of the body. Such changes are often quite as beneficial as complete rest. It has been recommended that the day be divided into three equal parts—eight hours for work, eight for refreshment and recreation, eight for sleep. Probably no better division can be made.

After a period of work, the muscles not only need rest, but *nourishment.* Proper exercise increases the strength of the muscles by causing them to receive more blood, and from it more nourishment. Exercise also helps them to throw off waste; thus the constant change that is needful to the health of every organ is brought about in the muscles by exercise. The strongest muscles are those that are most often used, provided they are properly rested. The weakest muscles are those that are least used. If the arm be bound motionless to the body, its muscles will in time grow pale, soft, and weak, and, by continued disuse, will become too feeble to raise the arm.

To be productive of good results, exercise needs to be taken at regular intervals, and at such times as not to interfere with digestion. Exercise should be taken in proper position, so that respiration and circulation may proceed rightly. It is best to exercise in the sunlight and open air. Sunlight has an invigorating influence upon all of the vital functions.

The employment of the muscles in exercise not only strengthens and develops the muscles, but it has a salutary effect on the whole system. The following quotation from an eminent author shows some of the beneficial effects of exercise of the muscles :

"When the muscles are put in action, the blood-vessels with which they are supplied become more rapidly charged with blood, and active changes take place in all the surrounding tissues. The heart is required to supply more blood, and it beats more rapidly to meet the demand. A larger quantity of blood is sent through the lungs, and larger supplies of oxygen are taken in and carried to the various tissues. The lungs and skin are brought into operation, and the lungs throw off large quantities of carbonic acid, and the skin large quantities of water, containing in solution matters which, if retained, would produce disease in the body. Wherever the blood is sent, changes of a healthful character occur. The brain and the rest of the nervous system are invigorated, the stomach has its powers of digestion improved, and the liver, pancreas, and other organs perform their functions with more vigor."

Very skillful movements of the muscles are acquired by repeated exercise of them under the direction of the mind. The ease with which one walks, speaks, writes, and performs the many extremely complex movements of daily life is due to constant effort and repetition.

The structure and movements of the hand are among the best illustrations of the wonders of the human body. Attached at the ends of the long arms, the hands command a space six feet in diameter, centered at the chest. The compound joints at the wrists give universality of motion; the thumb, supplied by many muscles, opposes itself with ease to any one of the fingers, or forms with them the hollow of the hand, or clasps against them the hand of another, or lays hold of any desired object. By muscular practice, in close union with thought, the hand becomes the forcible and significant instrument of expression by gesture, the rapid writer of words, the organ of delicate touch by the musician. It is estimated that, in the rapid playing of a skillful pianist, no less than nine hundred and fifty movements of the fingers are made in a minute.

10. The various parts of the body work together, and, in many cases, one portion depends upon another. Thus, the bones are moved by the muscles, the nerves control the muscles, the blood nourishes all parts, and the organs of digestion and breathing renew and purify the blood. If we desire to grow strong, we must not interfere with this dependence of one part upon another ; we must build up all ; we must renew the muscles not only by nutrition, but by suitable exercise and rest.

Some people imagine that they may make themselves strong by the use of **alcoholic drinks.** This is a serious mistake. These substances give a false sense of strength. They do not, however, add to our supply of energy; they merely excite us to use up our store of force more rapidly for the moment than we should otherwise do. We are consequently weaker after their temporary effect has passed off.

The activity of all of our vital organs is really muscular activity. Without the contractile powers of the muscles, nervous energy would be of no effect, the blood could not be purified, and nutrition could not be absorbed. And so dependent are the parts of the body upon each other that the weakening of one function is harmful to all. Alcohol weakens that great muscle, the stomach. Digestion being thus impaired, food is poorly assimilated, the blood is poorer ; that other great muscle, the heart, is weakened, and so on through all the bodily processes. Alcohol reduces the contractile power of all the muscles, and causes, in many cases, an abnormal deposit of fatty tissue between their fibers. This is called fatty degeneration.

The effect of **tobacco** on the muscles is to relax them—in other words, to weaken them. Accordingly, it is used in a few rare diseases, such as lockjaw, for this very purpose. Its tendency to impair the muscular action of the heart is well known. This may frequently result from even a moderate use of tobacco. Excessive use of the narcotic renders the muscular tissues of the heart flabby in texture and weak in action.

NAMES AND USES OF THE PRINCIPAL EXTERIOR MUSCLES.

Head :

1. Occipito-Frontalis	*elevates the eyebrows.*
2. Temporal	*raise the lower jaw.*
3. Orbicularis Palpebrarum	*closes the eye-lids.*
4. Masseter	*raise the lower jaw.*

Neck :

5. Sterno-Cleido-Mastoideus	*draws the head forward.*
6. Trapezius	*moves the head.*
7. Platysma Myoides	*lower angle of mouth.*

Upper Extremities :

8. Deltoides	*raises the arm.*
9. Biceps Flexor Cubitis	*bends the fore-arm.*
10. Brachialis	*acts on fore-arm.*
11. Triceps	*extends the fore-arm.*
12. Supinator	*turns the fore arm outward.*
13. Extensor Carpi Radialis	*extends the hand.*
14. Extensor Carpi Ulnaris	*extends the hand.*

Trunk :

15. Pectoral	*draws the arm forward.*
16. Latissimus Dorsi	*lowers the arm.*
17. Serratus Magnus	*elevates the ribs.*
18. Oblique	*form the walls of the abdomen.*
19. Rectus Abdominis	*supports the abdomen.*
20. Glutæus Medius	*moves the thigh.*
21. Glutæus Maximus	*moves the thigh.*
22. Tensor Femoris	*binds thigh muscles together.*

Lower Extremities :

23. Vastus Externus	*extends the leg.*
24. Biceps Flexor Cruris	*bends the leg.*
25. Gastrocnemius	*extends the foot.*
26. Tibialis Anticus	*bends foot on leg.*
27. Extensor Digitorum	*bends the foot and extends the toes.*
28. Soleus	*extends the foot.*
29. Peronæus Longus	*draws foot back.*
30. Peronæus Brevis	*draws foot back.*
31. Peronæus Tertius	*bends the foot.*
32. Abductor Minimi Digiti	*bends little toe.*
33. Extensor Pollicis	*extends great toe.*
34. Flexor digitorum	*bends the toes.*

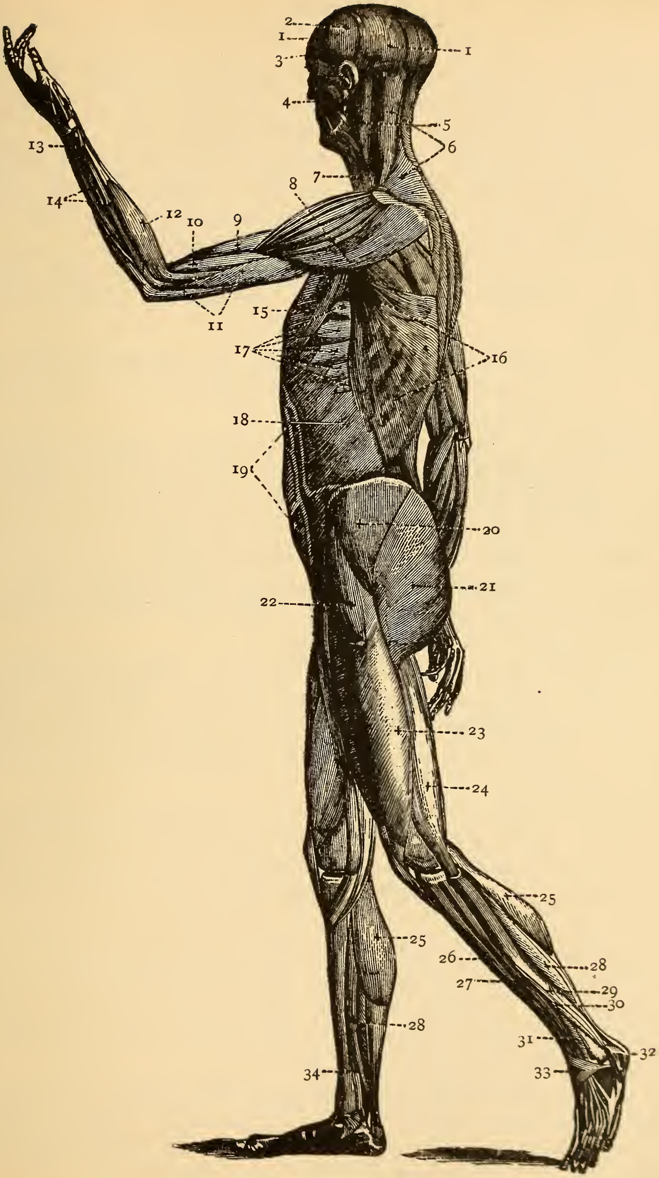


Fig. 29.

The Muscular System.

QUESTIONS.—1. What is the principal use of the muscles? How do they produce motion? Where are most of them situated? Are all muscles of the same shape? Name a hollow muscle.

2. Into what two great classes are muscles divided? Name some voluntary muscles. Some involuntary muscles. What is the principal function of each class? Describe a fiber of an involuntary muscle. To which of the two classes do most of our muscles belong?

3. How do the two kinds of muscular fiber differ from each other? What is the meaning of the word *biceps?* Describe the *structure* of the biceps muscle.

4. How do tendons look? What work do they perform? What can you say of their structure? Are they remote from or near to the joints? How are they strengthened, and where?

5. What part of muscular fiber is it that contracts in action? Describe the *action* of the biceps muscle. Where are the muscles that move the fingers? How are these muscles connected with the fingers? Through what medium does the will stir the muscles to activity?

6. What can you say as to the number of our muscles? How are they placed so as to coöperate? What is an antagonistic muscle? Give the meaning of the word *flexor.* *Extensor.* How must these two types of voluntary muscles be divided as to number?

7. Name some important muscles of the chest. What is the meaning of *intercostal?* Where are the intercostal muscles? What is the meaning of the word *diaphragm?* What two sets of organs does this muscle separate? In what vital function are the diaphragm and rib muscles mainly concerned?

8. Are you conscious of mental effort in maintaining the standing position? What name is given to the bodily consciousness by which we keep our balance in walking, standing, and the like? How is the muscular sense acquired? How may we know that it is different from the sense of touch?

9. Does the heart ever rest? When do the voluntary muscles rest? By what means are the muscles excited to demand nourishment? How is muscular waste removed? What can you say of the effects of exercise in training the muscles? What part of the body affords the best illustration of the results of muscular training?

10. How does alcohol affect the muscles of the stomach? The muscular action of the heart? What is "fatty degeneration"? How is tobacco sometimes used in medical practice? What muscular organ is specially injured by the use of tobacco?

CHAPTER IV.

THE SKIN.

Etymology of Terms.

ȼăp'il la ry (Lat. *caput*, head; *capillus*, hair; *capillaris*, hair-like, hence minutely tubular.

ȼôrn (Lat. *cornu*, horn).

ȼū'ti ȼle (Lat. *cuticula*, little skin), the less important skin.

ȼū'tis (Lat. the true skin).

dŭȼt (Lat. *ducere*, to conduct), a conduit or passage-way.

ḡlănd (Lat. *glandula*, a little acorn).

pōre (Lat. *porus*, an orifice).

săȼ (a word common to many lan guages), a sack.

sē bā'çeoŭs (Lat. *sebum*, tallow).

1. The skin forms a beautiful, pliable covering for the body. The beauty of the skin is partly due to the fact that it is translucent, disclosing the tint of the flesh and the delicate tracery of the veins. The skin is somewhat elastic, and glides a little upon the soft parts which it covers, thus admitting of free motion of the external muscles. In various ways it prevents the body from getting very hot or very cold, and by its toughness it shields the tender parts beneath it from injury. It is therefore an organ of *protection.* The nerves of the skin tell when an object touches us. Accordingly, it is the organ of the *sense of touch.*

The skin aids in removing waste matter from the blood. It is therefore an organ of *excretion.*

Since its uses are so numerous and different, the **structure of the skin** is necessarily complex. The skin is composed of two layers. The outer layer is called the cuticle. The inner layer is called the cutis. The cuticle is fitted closely upon the cutis. (See Figs. 31 and 32.) A blister is the accumulation of liquid between the two layers.

The cuticle is formed of tiny cells, closely packed together in layers. It really consists of a secretion somewhat like the whites of eggs, which hardens into a translucent membrane. The cells are flat, dry, and scaly on the outer surface of the cuticle, while at the base they are globular, soft, and growing. (See Fig. 30.) The outer cells are constantly wearing off by friction, and are being replaced by the new cells from below. The rapidity with which the cuticle is renewed is shown by the short time that stains remain upon the skin. The whole is renewed within a few days. The outer portion of the cuticle is horn-like, and resists the action of many substances which would injure the tender cutis. The protecting power of the cuticle is illustrated by placing the hand in brine, weak lye, or acid. The cuticle resists the action of these fluids, but if there is the least crack or scratch in the cuticle, the cutis burns and smarts. On the palms of the hands and soles of the feet, where the skin is subject to much pressure, the cuticle grows hard and thick. The cuticle frequently becomes greatly thickened by this pressure, so that it irritates the cutis beneath. Corns are produced in this manner by tight shoes.

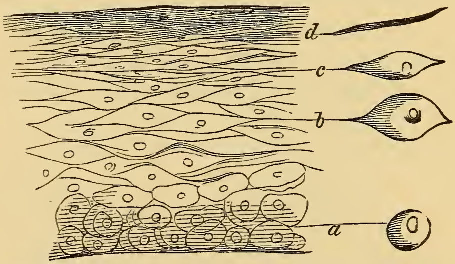


Fig. 30.

SECTION OF CUTICLE, MAGNIFIED.

a, deep cells ; *b*, *c*, cells more and more flattened ; *d*, scaly cells at surface.

The cuticle has no blood-vessels, hence it does not bleed ; it has no nerves, hence it is without feeling. At the base of the cuticle, the cells contain coloring matter, and as these colored cells vary in number, thickness, and hue, so does the complexion. The coloring substances are secreted into the cuticle from the cutis.

2. Hair and nails, though they bear no resemblance to it, are merely parts of the cuticle that are excessively developed.

The nails are formed of layers of cells that grow from a fold in the cuticle at the root of the nail, and from under the nail. Each nail fits into a groove of the cutis much as a watch glass fits into its rim. As the nail grows, the cells of the cutis move forward toward the end of the fingers and toes, so that the whole nail is renewed in about four months. The nails protect the ends of the phalanges from injury, and give firmness to the soft fleshy parts beneath. They preserve the sensitiveness of the finger-ends, and enable us to handle small objects with delicacy. (See Fig. 31.)

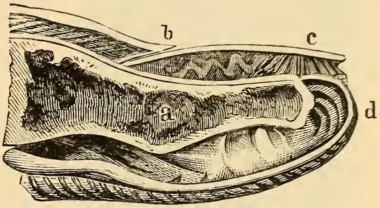


Fig. 31.

SECTION OF THUMB.

a, last phalanx of thumb; *b*, cuticle projecting upon nail; *c*, nail; *d*, cuticle.

Hairs are formed of cells from the cuticle. Each hair grows from the top of a tiny pear-shaped bulb at the base of a deep sac in the skin. This sac is formed by a depression of the cuticle far into the cutis. (See Fig. 32.) The hair is cylindrical, somewhat elastic, and horn-like. The outer part consists of a succession of rings which overlap one another much as do the tubes of a common spy-glass. It has a hollow throughout its length. This hollow is filled with air in the outer portion of the hair, and with liquid at its base. The coloring matter of the cuticle gives color to the hair. Each hair is nourished at its inner end by the blood-vessels of the cutis. Here also is a nerve by which, when a hair is pulled out, we receive a sensation of pain.

The hair grows from below, constantly pushing itself out through the sac, which slants a little so that the hair may lie flat on the surface of the skin. If the hair sac is destroyed the hair will not grow again.

On most of the body the hair is short and fine, and not to be seen except upon close scrutiny. On the palms of the hands and the soles of the feet there is no hair. On the head it is an element of personal beauty, besides affording protection from extremes of temperature and from blows and shocks. The brows and lashes of the eyes protect these delicate organs from dust and other injurious substances.

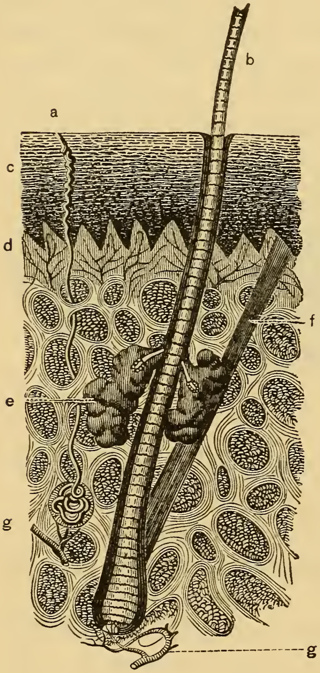


Fig. 32.

Section of Cutis and Cuticle.

a, perspiratory duct, with gland below; *b*, hair, with sebaceous glands below; *c*, cuticle; *d*, papillæ; *e*, fat cells; *f*, muscle; *g*, blood-vessels.

3. The cutis, or true skin, is exposed to view when the cuticle is removed. This part is thicker than the cuticle. The cutis is composed mainly of fibrous tissue, so interwoven as to make an elastic but very dense, tough mass. Leather, as it is prepared from the skins of animals, shows how largely the skin is composed of tough fiber. Throughout the cutis, there is distributed a network of minute blood-vessels, and the surface is thickly set with nerves. These blood-vessels and nerves are so numerous that the point of a needle can scarcely enter the cutis without drawing blood and causing pain.

When the cuticle is removed so as to lay bare the cutis, this is found to be studded with multitudes of minute, somewhat conical elevations, called *papillæ*. (See Fig. 32.) Similar tiny elevations may be seen and felt upon the surface of the tongue. They are largest on the palms of the hands and the soles of the feet. (See Fig. 33.) Some of these papillæ contain fine capillary loops in which the blood circulates; others have delicate nerves of sensation. (See *Nerves of Touch*, p. 178.) Where, as on the inner side of the fingers, these papillæ are largest, the outer skin is marked with alternate ridges and furrows. These may be plainly seen, arranged in curved lines, on the last phalanx of the fingers. The ridges show the position of the papillæ of the cutis; while the furrows are due to the sinking of the cuticle into the spaces between the rows of papillæ.

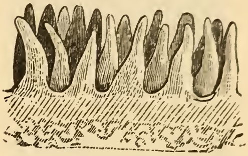


Fig. 33.

Papillæ of Palm of Hand, greatly magnified.

4. In the outer portion of the cutis are many small **glands.** These glands secrete an oily substance into the cuticle, and upon its surface. They are called *sebaceous glands.* (See Fig. 32.)

The sebaceous glands look somewhat like miniature bunches of grapes. They pour their oily secretion through tiny ducts or tubes into every hair sac. There are generally two sebaceous glands to each hair. One of the uses of the fluid they give forth is to make the hair pliable and glossy; but a far more important use is to give softness and flexibility to the outer skin, which would else become harsh and rigid. There are no oil glands in the palms and soles, where perspiration is copious. Those of the inner surfaces of the eyelids prevent the overflow of tears except when, as in weeping, the secretion of these is excessive.

In the cutis are tiny muscles which run from the base of each hair sac slantwise to the outer part of the cuticle. (See Fig. 32.) When these muscles contract they make the hairs stand on end, as in sudden chill and in fright. They also aid in forcing the oil out of the sebaceous glands.

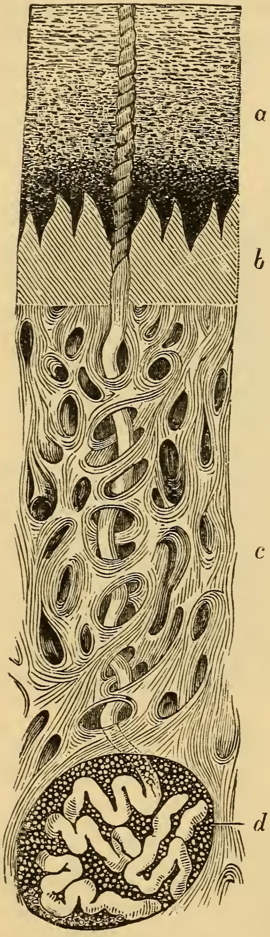


Fig. 34.

Section of Skin of Sole of Foot.

a, cuticle ; *b*, papillæ ; *c*, cutis ; *d*, perspiratory gland.

5. More deeply imbedded in the cutis, there are great numbers of very small glands that are coiled into knots. These are the *perspiratory glands*. (See Fig. 34.) They are so numerous that it is impossible to do more than roughly estimate their numbers. It is thought that there are between six and seven millions of these sweat glands in the human body. From each gland a duct, passing through cutis and cuticle, opens on the surface of the skin. In its passage through the outer skin the course of the perspiratory duct is usually spiral, and this tortuous course tends to prevent needless or excessive excretion from the glands. They receive moisture from the blood, and pour it out on the surface of the skin. This is called perspiration. Perspiration contains minute quantities of salt and other impurities from the blood, but consists almost wholly of water or watery vapor. Perspiration may take a liquid form, in which case it is called *sensible* perspiration ; or it may be in the form of vapor, in which case it is called *insensible* perspiration. The greater part of the perspiration from our bodies passes off insensibly. The daily amount of the skin's excretion is estimated to be about two pounds.

When the body becomes too warm, the pores of the skin open and the perspiratory glands receive more than the usual quantity of moisture from the blood. They pour this out on the surface of the warm skin, where it evaporates, and cools the skin and the blood that flows through it. In this way, the *temperature of the body* is kept from rising too high. One may readily observe how evaporation cools the skin by wetting one hand in warm water, and moving it rapidly through the air until dry. The hand that was wet soon becomes cooler than the other. When the body is exposed to cold, the pores of the skin close, and prevent much perspiration, so that the surface of the skin may be dry; this helps to keep the body warm.

6. Hygiene of the Skin.—The skin will absorb many substances that are placed upon it. These substances make their way through the walls of the blood-vessels, and by entering the blood are borne through the system. Oxygen from the air, water, and some liquid foods will enter the blood in this way in extremely small quantities. By this action of the skin contagious diseases are sometimes received by touch, and medicines applied to the skin affect the parts beneath.

Properly nourished and cleaned, the system is healthy and vigorous. If either of these two processes is arrested, or is imperfectly performed, the result is weakness and disease. Disease is not something which comes upon us from without so much as it is the result of faulty nutrition or defective removal of waste matter.

The skin is specially engaged in the excretion of matter. To keep the skin clean is to keep open one of the chief outlets from the system. Since the proper condition and action of the skin are necessary for the preservation of health, let us consider the most direct means by which the skin is affected. Two of these are: (1) The condition of the clothing, and (2) the cleanliness of the skin itself.

Clothing, especially that which is worn next to the skin, needs to be changed frequently, for two reasons: (1) to allow it to dry; (2) to keep it from being filled with effete matter from the body. When the clothing becomes filled with this, it prevents the skin from throwing off more waste matter from the blood. The underwear worn during the day should be laid off at night, so as to be freely aired. The bedding should be exposed to the light and air during the day. Clean under-clothing, by its friction against the cuticle, and by its tendency to absorb the moisture of the surface, aids greatly in causing a healthful action of the skin.

Clothing should protect the body against the cold of winter, the heat of summer, and the dangers resulting from sudden changes in temperature. Loose and porous clothing is warm. Woolen fabrics are most valuable in this respect. Garments made of wool are poor conductors of heat, and, when worn next to the skin, do not allow the warmth of the body to escape through them. They are not easily moistened by perspiration, and do not readily give off moisture by evaporation. Flannel worn next to the skin is, for the reasons just given, an excellent protection against sudden changes in temperature. In a climate such as exists in most of the United States, it is best to wear a suit of flannel under-clothing at all seasons of the year. In winter, the thickness of these suits should be increased until they will of themselves keep the body warm. Warmth is better retained by putting on several layers of light, loose-fitting garments than by fewer layers of heavy clothes. The clothing should be loose, that it may be warmer and that it may not press the body out of shape. Tight clothing, by pressing on the arteries and veins, prevents free circulation of the blood. Clothing that fits closely about the waist should not be worn, because it hinders the fullness of breathing. The weight of the clothing should be borne by straps across the shoulders, rather than supported by tight bands about the waist. In summer, cotton fabrics may replace the woolen. They more readily absorb the moisture of the skin, and lose it by evaporation.

7. Cleanliness of the skin may be impaired: (1) by excess of oily matter from the sebaceous glands; (2) by portions of perspiration; and (3) by dust. These various substances should be removed by bathing. For persons in good health, a daily cool bath will prove both pleasant and beneficial, if (1) the bath is accompanied by a thorough rubbing of the skin with a rough towel; and (2) it is followed by brisk exercise. For persons who are less robust, a bath once or twice a week, in a warm room, with tepid water, followed by thorough drying and rubbing, may be sufficient. Soap should be employed to remove the excretions that fill the pores and cover the surface. A harsh cloth or flesh brush should be used to detach the old scales of the cuticle. No one is in danger of suffering from cold or chill who takes his bath in a room heated to summer temperature, using water that is pleasantly warm, if he will thoroughly dry and chafe the skin until it glows with warmth. Brisk exercise may follow, as a means of causing continued flow of blood to the surface and extremities. By giving proper attention to the bath, and by wearing clean, warm, dry clothing, the skin may be kept in a healthy condition.

Healthy action of the skin is promoted by the influence of fresh air and sunlight. Outdoor sports, brisk walks, rides, and all kinds of work under the open sky invigorate every tissue of the body.

What is known as a **cold** is a congestion and inflammation of the linings of the throat and lungs, or of some other internal membrane. Usually this condition is caused by wearing damp clothes, by getting the feet wet, by the sudden cooling of the skin after exercise, by sitting or lying on the damp ground, by undue exposure of the extremities, by exposing some part of the body to a current of cold air, or by chill in some other way. In all these cases, the cause is one that affects the skin so that the blood current through it is chilled, and the blood is sent in undue quantities to the delicate surfaces within. Much may be done to relieve a cold by applying warmth to the extremities, and by such treatment as will relax the skin and excite it to an active condition of circulation and excretion.

The most common and most painful injuries to the skin are **burns and scalds.** If a burn is deep, it will destroy both cuticle and cutis and make a wound that will require a long time for recovery. The air should be excluded by some simple dressing, and the part should be kept clean and quiet, so that the skin may renew itself. Usually, in a burn, the cuticle only is raised in a blister, and this may produce acute pain for hours after the occurrence. To relieve the pain, it is necessary to exclude air from the burn. By submerging the burned part in cold water, or by wrapping the part in a bandage that is kept wet, or by coating the part with water and flour or sweet oil and cotton, the pain is relieved. A new cuticle soon begins to form next to the cutis, so that after a day's time or more the surface is covered and the injury is cured. (See p. 225.)

8. Persons who use **alcoholic liquors** sometimes have red faces with congested noses and eyes. This is because the alcohol has paralyzed the delicate nerves of the blood-vessels, and the tiny capillaries have become enlarged and filled with blood.

The blood coming from the interior is warmer than the surface of the body, and as it flows through the blood-vessels of the skin a feeling of increased warmth is produced ;

but this excessive flow of blood to the surface of the skin gives rise to a corresponding increase in the radiation of heat from the skin, so that the temperature of the skin is finally reduced below its natural point, to the injury of all its functions. Alcohol, therefore, so far from being a protection against the cold, renders one much more liable to take cold.

Alcohol not only paralyzes the nerves which control the blood-vessels, but also deadens the nerves of touch, so that one who is under its influence does not feel so sensitively as he otherwise would; hence arises another danger in the use of alcohol in cold weather, as its tendency to render us unconscious of the cold, by deadening the senses, is likely to make us neglectful of proper protection against the cold.

QUESTIONS.—1. What are the principal uses of the skin? What is excretion? Give the meaning of the word *cuticle.* What is the true skin? Of what sort of matter is the cuticle composed? What is the chief use of the cuticle? Describe its structure. Is it a living substance? Is it transparent?

2. What two special forms of development has the outer skin? How do the nails grow? How are they useful? Describe a hair sac. The structure of the hair itself Its growth. How are the hairs nourished? How are they useful?

3. Describe the cutis. Is it sensitive? Does it wear away by friction? Describe the papillæ. What name is given to the minute blood-vessels of the papillæ?

4. What is the derivation of the word *sebaceous?* Where are the sebaceous glands situated? Describe their appearance. Their uses. The palms and soles—have they sebaceous glands? Hairs? Does hair grow vertically through the skin? How may hairs be made to stand erect? What other use have their tiny muscles?

5. Where are the perspiratory glands? Describe the course of the ducts which lead from them. Why is this course irregular? Of what does perspiration consist? What two forms may it take? What is the daily amount of this excretion? What are the principal uses of perspiration?

6. What is the most important function of the skin? What, therefore, is most necessary to its health? How is the hygiene of the skin affected by the nature and condition of the clothing? Give some simple rules on this subject.

7. What is the use of the bath? How is the skin affected by exercise? What is a cold? How are the cuticle and the cutis most commonly injured? What is a blister?

8. How does the use of alcohol affect the skin? How may this be seen? What is the influence of alcoholic drinks upon the temperature of the body? How does it render us liable to take cold? What is its influence upon the sense of touch?

CHAPTER V.

FOOD.

Etymology of Terms.

al bū'men (Lat. *albus*, white).

as sĭm'i late (Lat. *assimilare* to render similar).

c̶ā'se ĭn (Lat. *caseus*, cheese).

dis tĭll' (Lat. *stilla*, a drop).

ex̱ hāle' (Lat. *exhalare*, to breathe out).

fer men tā'tion (Lat. *fervere*, to boil; hence, *fermentare*, to agitate internally).

le ḡū'mi noŭs, (Lat. *legere*, to gather, so called because pods are easily gathered), having legumes or pods.

tū'ber (Lat., a knob), a round root.

vī'nous (Lat. *vinosus*, winy; from *vinum*, the grape).

vŏl' a tĭle (Lat. *volare*, to fly), easily evaporated.

1. The life of the body involves constant changes in the substances of which it is composed. There can be no activity of any part of the body—that is, it can have no life—without what are known as waste and repair of tissue. The effete matters which constitute the waste must find their way out of the body by the various processes of excretion. To make good the loss, other substances from without must be taken into the body. Air must constantly pass into the lungs; solids and liquids must pass into the stomach. All nourishing substances taken into the stomach are food. As might be inferred from the fact that the body is continually renewed by the food taken into it, body and food are made up of substances that are identical in their nature. Almost all of the bodily organism is made up of carbon, hydrogen, nitrogen, and oxygen. These elements are, therefore, sometimes called organogens—that is, "makers of the organism."

2. Every one is familiar with hunger and thirst. These feelings are demands for solid and liquid food. Food is required for the growth of the body, to maintain its warmth, and to repair the wastes caused by exercise. The kinds and quantities of food needed vary with age, sex, occupation, and health. It is estimated that a healthy man requires daily about one and two thirds pounds of oxygen from the air, four pounds or less of water, and about two and one third pounds of solid food, making about eight pounds during the twenty-four hours.

Our food is obtained from minerals, plants, and animals. The most nourishing food is obtained from plants and animals. Substances of this kind are called organic substances, because they are derived from living things, all of which have vital parts that are different from one another. These parts, whether simple, as in the potato, or complex, as in the ox, are known as organs. Substances which are homogeneous throughout—that is, all of whose elements are of like structure—and which have no organs and therefore no life, are inorganic substances. Such is the nature of all minerals.

3. The mineral or inorganic substances that serve as food are: (1) water, which is supplied in the usual forms of drink, and is also part of many kinds of foods, especially of fruits; (2) various salts, such as common table salt, lime salts, and iron salts.

Water is required in the system for many reasons. By its moisture it softens the various tissues, and thus permits free movement of the muscles and of all parts of the body that are engaged in vital processes. Water dissolves the food we eat, all of which must be changed to a liquid form before its nutrition can be absorbed. The blood, which carries the absorbed nutrition throughout the body, and by means of which waste substances are in turn removed from the body, is mainly water. So, also, the numerous bodily secretions, and the substance of the nerves, are largely composed of water. Accordingly, this essential element forms more than two thirds of the whole weight of the body. Men can survive only for a few days without water, but they can live for many weeks without solid food.

Salts are required to build up the teeth, bones, and some other parts. Many of the salts that are taken as food are contained in the water we drink and in the grains we eat. They are serviceable in promoting the various secretions, especially those which aid in carrying off waste matter from the system.

Mineral food differs in one important respect from the organic substances that we eat. Water and salt are not oxidized in the body—that is, they undergo no change of their own constitution. They are merely used, as water and as salt. On the other hand, food that consists of organic substances undergoes what is called chemical change —that is, its constitution must be altered before such food can be assimilated and adopted into a new organism, that of the human body.

4. The food substances obtained from animals and plants, and which are called **organic substances**, consist of : (1) albuminoids ; (2) fats ; (3) sugars.

Albuminoid foods are much like the various tissues of the human body, and are therefore chiefly valuable for the building up of these tissues. Albuminoid foods are so called because they contain albumen, a substance found nearly pure in the whites of eggs. They seem best suited for nourishing the body, while at the same time they serve in part to produce its warmth. The most important articles of this group of foods are *albumen*, *gluten*, *fibrin*, and *casein*. Gluten abounds in lean flesh and in wheat and other grains. It is this substance that gives adhesiveness to dough, making it *glutinous*. Fibrin is characteristic, as the name denotes, of the various fibrous tissues.

Coagulation of the blood is due to the properties of the fibrin it contains. The juice of meats is rich in this element. Casein forms the solid part of milk, and most of the substance of cheese. It is also abundant in the edible seeds of leguminous plants, such as pease, beans, and peanuts. Persons who take much muscular exercise require food of this kind.

5. Fats are foods that are like the fatty portions of the body. The chief use of the fats is to keep the body warm. They serve somewhat to nourish the tissues and to preserve their strength. This kind of food is supplied by fatty meats, butter, kernels of nuts, and many oily grains and seeds. It is specially needed by the body during the winter season.

Sugars include starch and gums, and compose a large portion of ordinary foods. These substances are all vegetable in their origin, and are found abundantly in corn, rice, wheat, potatoes, and ripe fruits. They serve admirably both to nourish and to warm the body. Observation and experience indicate that foods of this kind are to a great extent the proper diet for the people who live in the temperate regions of the earth.

6. An illustration of the nice adjustments which nature everywhere makes is afforded by the geographical distribution of man's food supply. In the polar regions, vegetation is scanty, and man's diet is confined to the animal fats which he specially needs to maintain his bodily heat. The most active and progressive races of men, who consume the bulk of the world's cereal products, inhabit the temperate zones, and it is in these that all of the food-grains flourish best. Fruits in great variety abound in torrid latitudes, where the climatic heat makes man independent of animal fats and other stimulating foods.

Yet **diversity of food** is unquestionably beneficial, and by the most highly civilized races of mankind is especially demanded. One has only to observe how sameness of diet palls upon the appetite, and how variety of food quickens and stimulates it, to realize the benefits of a mixed diet. The gratification which a new dish affords to the senses is not meaningless, but points to a physiological truth. Such gratification stirs the nervous system to activity, and this in turn increases the vigor of the circulation. Nutrition is thus not only better absorbed by the digestive apparatus, but better distributed to all parts of the body.

Animal foods furnish albuminoids and fats, in 100 parts, as follows :

Eggs,	Albuminoid	14,	Oil	11.
Beef,	"	8,	"	30.
Cheese,	"	29,	"	30.
Butter,	"	1,	"	88.
Milk,	"	4,	"	4.

Vegetable foods produce the three classes of foods about as follows, in 100 parts :

Oat Meal,	Albuminoid	16,	Starch	63,	Oil	1.
Corn Meal,	"	9,	"	65,	"	5.
Wheaten Flour,	"	11,	"	74,	"	1.
Rice,	"	8,	"	76,	"	1.
Potatoes,	"	2,	"	15,	"	0.

Cooking is designed : (1) to render food more digestible ; (2) to develop its flavors and thus make it more inviting to the senses ; and (3), especially with meats, to destroy any germs of disease that may be in the food.

7. Alcohol resembles water in appearance, but is lighter than water. It has a mild odor, a pungent taste, is very volatile, and burns readily. It will dissolve gums, oils, and resins ; hence it is much used in making varnishes. Because of its power of dissolving gums and oils, it is used in extracting these substances from various leaves, barks, seeds, and roots, so that a large class of alcoholic tinctures is thus made. What is called a tincture is simply spirits *tinged* or penetrated by some substance that is held in solution by the alcohol.

Alcohol is produced by the **fermentation** of sugar. Sugar is a vegetable product ; so also is starch. Since starch can be converted into sugar (p. 85), these two substances may be viewed together as the usual sources from which alcohol is produced. The starch and sugar used for this purpose are derived from various fruits, grains, and tubers, such as the apple and the grape, corn and rye, the potato and the beet. Vast quantities of these articles, so commonly used for food, are employed each year in the making of alcohol.

8. By the process of fermentation, sugar is decomposed, so that it ceases to be sugar, and becomes two other substances : (1) a volatile and poisonous liquid, called alcohol ; (2) a gaseous fluid, called carbonic acid. Sugar does not of itself readily decompose, but when certain substances are put with the sugar, it speedily undergoes change.

The juice of apples is sweet, when first made into cider, because of the sugar in it. If the cider is kept at a summer temperature, it rapidly undergoes a change, by which bubbles of gas arise from it, and it loses its sweetness, and acquires a very different taste and odor. The sugar in the cider changes to carbonic acid, which forms the bubbles of gas, and to alcohol, which gives the new taste and odor.

If we take a few drops of ordinary molasses and mix with them some warm water and a little baker's yeast, the sugar of the molasses will turn to carbonic acid and alcohol.

If grains of barley are kept moist and warm they will begin to grow. If we chew these growing grains we shall find them sweet. Their starch has partly turned to sugar. If this sugar is dissolved out of the barley with the right amount of water, and yeast is added, and this mixture is kept warm, *vinous fermentation* will take place; that is, the sugar will turn to carbonic acid and alcohol. With other substances added for flavors, such a liquor is called ale or beer, and is dangerous because of the presence of alcohol, which even in small quantities arouses an appetite for more.

9. If such fermented liquors as cider and light wines are left exposed to warm air, fermentation will continue, changing again the nature of the liquor fermented; for vinous fermentation will give place to *acetic fermentation*, in which the alcohol in the liquor will turn to an acid called acetic acid or vinegar, which is not a poison, but is used as a relish for food.

Alcohol boils at a lower temperature than water. By heating a mixture of water and alcohol until it is above the boiling point of alcohol, but below the boiling point of water, we may drive the alcohol off in the form of vapor, and have the greater portion of the water left behind. If the vapor is condensed drop by drop in a cold vessel, we shall have all of the alcohol and some of the water. This process is called **distillation.** In this way distilled liquors are made from fermented liquors.

Cider, beer, wine, and whisky contain alcohol. It is this that gives to them their intoxicating properties. While cider and beer are composed mainly of water, the alcohol they contain leads to their use as beverages.

The following classification of alcoholic beverages shows the percentage of alcohol in each:

		PER CENT.
Fermented	Cider, . .	3 to 10
	Beer, . .	3 to 10
	Ale, . . .	6 to 10
	Claret, . .	7 to 9
	Champagne,	5 to 13
	Madeira, .	16 to 25
	Port, . .	16 to 25

		PER CENT.
Distilled.	Rum, . .	60 to 70
	Whisky, .	50 to 60
	Brandy, .	50 to 60
	Alcohol, ordinary,	75
	Alcohol, absolute,	95

10. Alcohol is not food. It creates thirst. It does not satisfy hunger. Its action on the muscles and nerves produces excitement and inflammation. It tends to disorganize the blood, so as to bring about diseased conditions of the heart, liver, and brain. Food satisfies hunger, and maintains the warmth and vigor of the body. If much alcohol is taken into the stomach, it passes directly into the blood, and is distributed throughout the body. It goes into the blood as alcohol. It is distributed as alcohol. It is finally cast out of the body as alcohol. It undergoes little change in the body. It does not supply any lasting strength to the tissues. Food and alcohol are directly opposite in their action.

That alcohol does not serve to nourish the body is shown by the following contrasts :

A true beverage slakes thirst, and furnishes water to the tissues.

Food is nutritious ; it enters the blood in a new guise ; it satisfies hunger ; it furnishes material for rebuilding the tissues.

Heat-producing articles finally increase the temperature of the body, and the amount of carbonic acid exhaled.

Alcohol produces thirst, and takes water from the tissues.

Alcohol is innutritious ; it enters the blood unchanged ; it does not relieve hunger ; it furnishes no material for rebuilding the tissues.

Alcohol finally lowers the temperature of the body, and diminishes the amount of carbonic acid exhaled.

An eminent authority says : " The use of alcohol in combination with water, and with organic and saline compounds, in the various forms of fermented liquors, deserves particular notice, on account of the numerous fallacies which are in vogue respecting it. It may be safely affirmed that alcohol can not answer any one of those important purposes for which the use of water is required in the system; and that, on the other hand, it tends to antagonize many of those purposes. There is no reason to believe that alcohol, in any of its forms, can aid directly in the nutrition of the tissues, for it may be certainly affirmed that it is incapable of transformation into albuminous compounds; and there is no sufficient evidence that even fatty matter can be generated in the body at its expense."

The chief use of alcohol is in the form of intoxicating drinks. The *adulteration* or corruption of these drinks is extensive. Among the poisonous substances used in such adulterations are white lead, sugar of lead, copperas, logwood, alum, opium, aloes, tobacco, nux vomica, arsenic, strychnine, and sulphuric acid. Alcohol is itself poisonous, and the addition of such substances renders the use of alcoholic liquors so much the more injurious and dangerous.

QUESTIONS.—1. What are waste and repair of tissue? Can there be life without change? What is food? Our bodies are built up from food —What inference as to the nature of both body and food may be drawn from this fact? What is the difference between food and nutrition?

2. Name the chief practical uses of food. What amount of food is daily needed by a healthy adult? Whence do we derive food? What is an organic substance? An inorganic substance? To which class do the minerals belong?

3. What mineral substances are important items of our food? Name some important use of water. What proportion of the whole body does this element form? How are salts useful to the human organism? Is mineral food assimilated by the body?

4. Into what three classes are organic foods divided? Why are the albuminoids so called? What is the derivation of the word *albumen?* In what particular way do foods of this class benefit us? What makes dough glutinous? Of what are the fibrous tissues made? What is casein? What foods are rich in gluten? In fibrin? In casein?

5. What is the use of fatty food? In what season of the year, therefore, is it best to eat it? From what sources do we derive it? What class name is given to starches and sugars used as food? From what type of organism are all sugars derived?

6. Could an Esquimau live on fruits? In what zone is a variety of

food best? What zone is the home of the most civilized nations? How may we know that a mixed diet is beneficial to us? Do we cook oranges and melons? Why not? Do we cook meats? Why?

7. What is alcohol? Name some of its useful properties. By what operation is alcohol produced? From what kind of substances is it mainly derived?

8. What substances result from the fermentation of sugar? How does cider become alcoholic? What is vinous fermentation?

9. How is vinegar made? What name is given to the process? Can the milder alcoholic liquors be changed into stronger drinks? How? Name the process. What is the derivation of the word *distill?*

10. Is alcohol a food? Is it nutritious? Does it help to build up the bodily tissues? Name some substances that are often mixed with it.

CHAPTER VI.

DIGESTION.

Etymology of Terms.

ăl'i ment (Lat. *alere*, to feed).
ăn'nu lar (Lat. *annulus*, a ring).
bī cŭs'pid (Lat. *bis*, twice, *cuspidatus*, pointed).
chȳle, chȳme (Gr. *cheëin*, to pour out).
dĕn'tĭne (Lat. *dens*, tooth).
dĭ gĕs'tion (Lat. *digerere*, to dissolve, separate, distribute).
e sŏph'a gŭs (Gr. *oisophagos*, food-carrier).
găs'tric (Gr. *gaster*, stomach).
in tĕs'tĭne (Lat. *intus*, inside).
lăc'te al (Lat. *lac*, milk; *lacteus*, milky).
mĕs'en tĕr y (Gr. *mesos*, middle; *enteron*, intestine).
mō'lar (Lat. *molere*, to grind in a mill).
păn'cre as (Gr. *pan*, all; *kreas*, flesh).
pa rŏt'id (Gr. *para*, near; *ous*, the ear).
pĕp'sin (Gr. *peptein*, to digest).
py lō'rus (Gr. *pulōros*, gateman).
vĭl'lus (Lat., a tuft of hair).

1. The complex processes by which parts of our food are prepared to nourish the body, and other parts of our food are excreted or thrown off from the body, are called **digestion.** The parts of the body in which food undergoes these changes are called the digestive organs. *Nutrition* renews and builds up, *excretion* clears away and purifies. These two acts performed by the digestive organs, aided by the lungs, kidneys, and some other organs, form the one great process of life in the body.

Digestion is mainly performed in a long, worm-like tube, called the **alimentary canal.** The alimentary canal begins at the mouth, and extends through the entire length of the trunk. This canal is formed of three coats or walls. The inner wall is soft and moist, like the lining of the mouth, and is called the mucous membrane. The middle coat is muscular, some of the muscular fibers running lengthwise, and others, arranged in rings, running crosswise. The outer coat is smooth and soft, and is of the same nature as the membrane which lines the whole abdominal cavity, and which coats all of the organs that are enclosed in this cavity.

Certain parts of the alimentary canal have received special names. The opening back of the mouth is the *pharynx*. The straight tube, about nine inches long, leading downward from the pharynx is the *esophagus* or gullet. At the lower end of this tube is an enlargement of the canal, forming a pear-shaped sac. This sac is called the *stomach*. It will hold about three pints. Connected with the stomach is a winding tube an inch or more in diameter and about twenty-five feet in length. This tube is called the *intestines*.

Tributary to the intestines are two great glands which pour fluids of their own into the digestive canal. The larger of these is the *liver*, the smaller is called the *pancreas*. Important organs in the excretion of liquids and salts are the *kidneys*.

2. Mastication, or chewing, is performed in the mouth. The food is held between the *teeth* by the lips, cheeks, and tongue, and is turned over and over by them. The strong muscles upon the sides of the head, by moving the lower jaw in several directions, cause the teeth to cut and grind the food. The teeth are exceedingly hard bodies, set firmly and deeply in the bones of the jaws.

Each tooth presents three parts: (1) the *crown*, which is the portion seen above the gums; (2) the *root*, the portion imbedded in the jaw; (3) the *neck*, or middle portion surrounded by the gums.

The main substance of the tooth is a hard, bone-like matter, which is known as dentine. (See Fig. 35.) Common ivory is dentine. The crown is covered with a thin layer of dense, hard substance, called enamel. The enamel is much like flint or glass, and is the hardest kind of matter in the body. The inner portion of the tooth, which is soft and pulp-like, contains the nerves and blood-vessels. The nerves and vessels enter through very small openings in the ends of the roots. The sockets in the jaw, and the roots that fit into them, are covered with a packing of fibrous matter which holds the teeth firmly in their places, and which serves as a cushion to prevent jar from biting hard food. The gums are composed of fibrous tissue, covered with a layer of mucous membrane. They aid in holding the teeth in place.

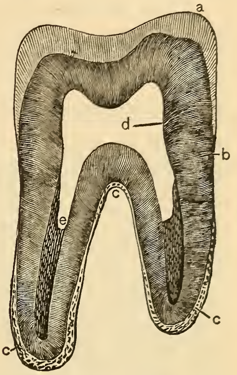


Fig. 35.

Magnified Section of Molar.

a, enamel of crown; *b*, dentine; *c*, cement; *d*, pulp cavity; *e*, passage for nerves and blood-vessels.

3. There are two **sets of teeth**: (1) temporary, and (2) permanent. The **temporary teeth** are twenty in number, ten in each jaw. The four front teeth of each jaw are flat and sharp, and are called *incisors*, or cutting teeth; on each side of these are pointed, or *cuspid* teeth, two in each jaw; and back of these, two on each side of both jaws, are grinding, or *molar* teeth. The teeth of this set begin to appear when the child is but a few months old, and all have cut through the gums by the end of the third year. From the fifth to the eighth year they are gradually removed by a second set, that grow beneath

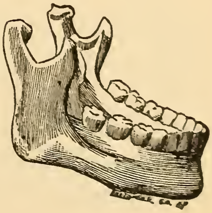


Fig. 36.

Lower Jaw-bone, showing Teeth.

them in the jaw, so that the teeth of the first set become loose, and are easily removed.

The permanent teeth are larger and stronger than the temporary ones, and are designed to serve during the remainder of life. (See Figs. 36 and 37.) There are thirty-two in this set, sixteen in each jaw, as follows: eight *incisors*, with four *cuspids*, back of which are eight *bicuspids* (two-pointed), with twelve *molars* far back in the mouth. The incisors and cuspids have a single root; the bicuspids and molars have two or more. The last molars do not make their appearance till after the twentieth year.

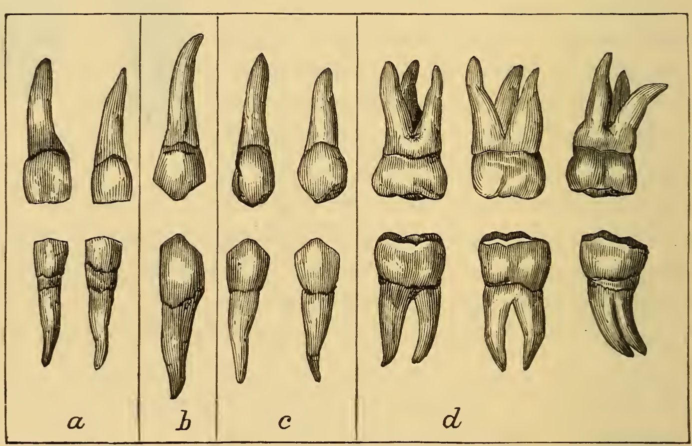


Fig. 37.

Permanent Teeth of the Left Side.

a, incisors; *b*, cuspids; *c*, bicuspids; *d*, molars.

The enamel of the teeth, while it is extremely hard, and resists the decomposing influence of almost all substances, may be cracked or broken by very hot or very cold food, by breathing very cold air through the mouth, and by collision with very hard material, as, for example, with the shells of nuts. Once injured, it is never restored.

When any of the enamel is removed, decay of the dentine sets in, and the tooth soon presents a cavity. The decay, as it reaches the nerves within, gives rise to toothache, and if not arrested will destroy the tooth.

4. During the process of mastication the food is thoroughly moistened by a mixed fluid which flows into the mouth from three pairs of glands, known as **salivary glands.** All glands take fluids from the blood. They change these fluids into juices which they pour out for special purposes. Thus, as we have seen, the perspiratory glands secrete perspiration. The salivary glands are located as follows : (1) the *parotid glands*, just below and in front of the ears ; (2) the *sub-lingual*, under the tongue, and (3) the *sub-maxillary*, under the jaw. Each of these glands is composed of a mass of tiny sacs and tubes, as represented in Fig. 38. The presence of food in the mouth, and the contraction of the muscles of the face in the act of chewing, cause these glands to take watery fluid from the blood and to pour it, in the form of saliva, into the month. The saliva moistens, warms, and softens food so that it may be easily swallowed. It also helps to dissolve the starchy part of the food and turn it to sugar.

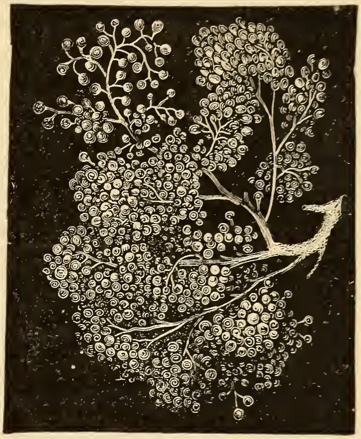


Fig. 38.

Parotid Gland and Duct.

Starch and sugar are of the same chemical composition. The digestion of starch consists in changing it into a form of sugar. This is done by the alkaline saliva, and by the acids and fermenting juices of the stomach and intestines. Starch will turn to sugar by being boiled with weak sulphuric acid. In all fermentation of starchy grains, the starch turns to sugar. Bread, potatoes, and other vegetables are largely composed of starch.

The importance of proper mastication is evident, because in no part of the alimentary canal except the mouth can food be cut and ground. The more thoroughly food is chewed and mixed with saliva, the more readily it is digested. Thorough mastication also develops the flavors of food and thus makes the saliva flow more freely. Food that is not thoroughly chewed is not properly started in the process of digestion.

5. When food is ready to pass from the mouth, it is pressed far back by the tongue, and thence from sight and control into the funnel-shaped opening of the throat, called the *pharynx.* The tongue is a very mobile muscle, and in directing the movements of food between the teeth and in swallowing is aided by the sense of touch, which in this organ is delicate and keen. The food passes next into the *esophagus,* in which the muscular fibers above contract, and those below it relax, so that the food is swallowed into the stomach. How the food is forced along the esophagus is illustrated by a horse as he drinks. Although his head may be low, he readily swallows the water upward into his stomach by contracting the muscles of the esophagus, and causing this contraction to run along the tube. (See Fig. 39.) In describing the middle or muscular coat of the alimentary canal, it was pointed out that some of the muscular fibers run lengthwise and some crosswise. As seen in the case of the esophagus, so throughout the digestive tract, these round muscles and

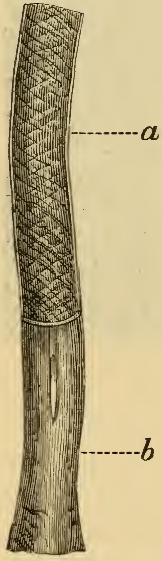


Fig. 39.

Esophagus, cut to show Muscular Fibers.

a, oblique fibers; *b*, lengthwise fibers laid bare.

long muscles, by their alternate action compel a slow movement of food substances along its course. They also promote the flow of the different digestive juices, the thorough mingling of these juices with the food, and the absorption from the mixture of its nutrient elements. By reason of these absorptions by the organs in their order, the bulk of the alimentary mass is continually lessened as it progresses through the body.

The *esophagus* passes from the throat downward behind the windpipe, and into the stomach through an opening in the diaphragm near the spinal column. Opening out of the throat are five passages besides the one through which food passes—two *nasal openings*, two canals leading to the ear, known as the *Eustachian tubes*, and the *windpipe*, which leads to the lungs.

In the act of swallowing, the hanging lobe called the *soft palate* is thrust upward and backward against the nasal passages, and the ear tubes are closed by muscular action. The windpipe is guarded against the entrance of food by a cartilaginous lid called the *epiglottis*. At the moment of swallowing, this lid is pushed downward and closed by the root of the tongue and by the food, which then glides over it. After the food has passed, the epiglottis opens again, leaving unobstructed the air passage to the lungs.

6. The trunk is naturally divided into two parts, the *chest* and the *abdomen*. Between the chest, which contains the heart and the lungs, and the abdomen, which contains most of the organs of digestion, is stretched a great muscle, arching upward at the center. This muscle is called the *diaphragm* (Fig. 49), and is treated of in the chapters on "THE MUSCLES" and on "RESPIRATION."

7. The stomach is placed just below the diaphragm, in the upper part of the abdomen. It lies obliquely across the body, with the large end toward the left side. In the adult, and after a full meal, it is about a foot in length, and nearly half as wide. Fig. 40 represents the stomach and the liver as they lie opposite each other across the body, the stomach on the left, and the liver on the right side. The liver is represented as turned upward, to show its under surface. The esophagus leads into the stomach from above, through an opening which is called the *cardiac orifice* because it lies in the region of the heart. There is an opening at the smaller end of the stomach, called the *pylorus*, and this leads into the smaller intestine, later to be described. The pyloric end of the stomach is lower than the cardiac end, and is separated by the liver from the diaphragm. These openings are guarded by *annular* or *ring muscles*, which keep the stomach closed during digestion by this organ, and whose general action is to prevent food from moving in any but a forward direction.

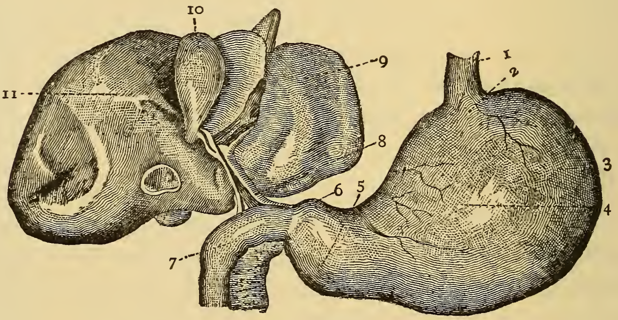


Fig. 40.

STOMACH AND LIVER, AS SEEN FROM THE FRONT.

1, esophagus; 2, cardiac entrance; 3, large end of stomach; 4, central portion; 5, small end of stomach; 6, pylorus; 7, duodenum; 8, gall duct; 9, left lobe of liver; 10, gall bladder; 11, right lobe of liver.

When food enters the stomach, this organ is excited, and aroused from a quiet condition to one of activity. The blood flows to it in increased amount, so that its inner coat turns from a pale color to a deep red. The lining membrane becomes filled with the blood that flows into its minute blood-vessels. In this inner coat there are multitudes of tiny glands. When the blood flows freely to the stomach, these glands secrete large quantities of *gastric juice* upon the food, just as the salivary glands pour out saliva in the mouth.

Gases and liquids pass readily through moist membranes. If a bladder that is filled with brine be placed in a basin of fresh water, some of the brine will pass out through the walls of the bladder, and some fresh water will pass in. The watery part of the blood passes in this way through the walls of the capillaries and glands.

The *gastric juice* is colorless, and consists of water, containing some mild acids, and a peculiar substance called *pepsin*. The gastric juice is poured out as it is needed, the quantity varying with the amount of food received by the stomach. It is by the action of the pepsin in the warm acid fluids of the stomach that the albuminoid foods are digested. The foods are all minutely divided and thoroughly dissolved by the warm liquids and by the motion of the stomach. In the walls of this organ, the muscular fibers are not only lengthwise and crosswise, as in other parts of the alimentary canal, but a third system of fibers runs obliquely around the stomach,

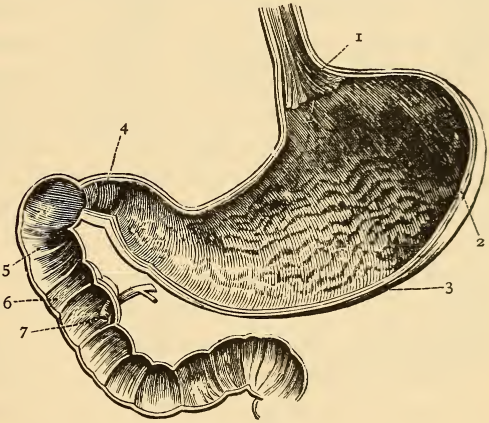


Fig. 41.

Section of Stomach.

1, cardiac orifice; 2, folds of mucous membrane; 3, muscular wall; 4, pylorus; 5, duodenum; 6, folds of mucous membrane; 7, entrance of bile and pancreatic juice.

crossing both the other sets. By the coöperation of these different sets of muscles, all parts of the lining membrane of the stomach are in turn brought into contact with the food. The motion of the stomach is a gentle rolling and rubbing of its walls. This kneads and churns the food contents, and moves them slowly from end to end.

As the *albuminoids* are prepared to enter the blood, they gradually pass directly through the mucous lining of the stomach into the blood-vessels. Some water and sugars also are here taken into the circulation, and the gastric juices are reabsorbed. After being passed through the liver to the heart, the nutrient elements of food find their way to all parts of the body, so that hunger is soon satisfied, and the strength of the body is increased.

Such portions of the food as are not digested in the stomach pass gradually, as a thin grayish mass, which is called *chyme*, through the pylorus into the intestine. The starches and fats are the most important parts of the chyme. The stomach takes up some of the starches, but none of the fats. The stomach, after two or three hours of active labor, is again empty, and takes its season of rest and repair. Fig. 41 gives an internal view of the stomach. Through permanent openings accidentally made into the stomachs of human beings, and openings purposely made into the stomachs of domestic animals, the process of digestion has been fully observed, and many experiments have been made to test the digestibility of various kinds of food.

8. The intestines are divided into two parts, the small intestine and the large intestine. The *small intestine* is a crooked contractile tube about twenty feet in length, lying in folds in the central portion of the abdomen. It leads into the *large intestine*, or colon, which forms the last five feet in length of the alimentary canal. The small intestine is somewhat more than an inch in diameter; the large intestine is about double that thickness. In Fig. 42 we see the small intestine as it is folded into a great mass in the central part of the abdomen, with the large intestine placed around it. The coats of the intestines are the same in kind, number, and arrangement as those of the other parts of the alimentary canal, only they are much thinner. These coats have numerous glands in them which secrete digestive fluids of their own, called intestinal juices. The inner coat is not only folded, as is that of the stomach, but it is very thickly set with minute *villi*, or hair-like rootlets. Millions of these project from the inner lining of the intestines, giving the membrane a softness that has been likened to the nap of velvet. The villi dip into the food matter so as to afford every opportunity for the absorption of nutrient particles, as the food is passed along by the worm-like motion of the muscular coat. Each villus contains blood-vessels, muscular fibers, and a lacteal, later to be described. (See Fig. 43.)

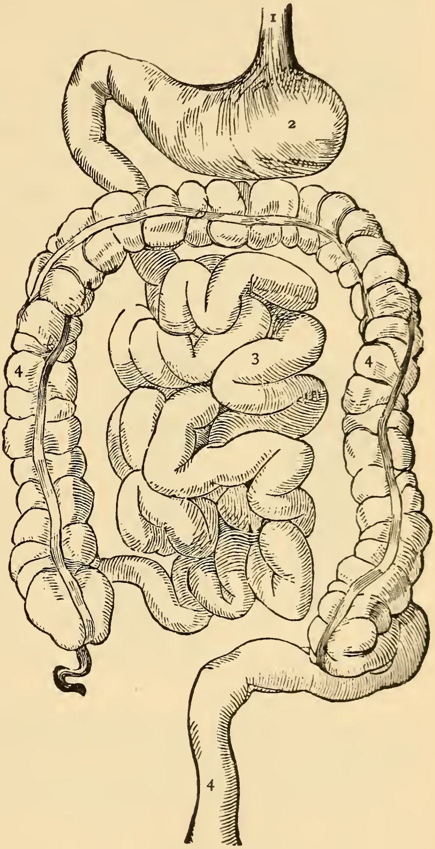


Fig. 42.

ALIMENTARY CANAL.

1, esophagus; 2, stomach; 3, small intestine; 4, large intestine.

The first few inches of the small intestine, called the *duodenum*, serve somewhat as a second stomach. It is here that two peculiar fluids are received by a duct, one branch of which brings in bile from the liver, and the other, pancreatic juice from the pancreas.

The liver is a large, dark gland, weighing three or four pounds, situated on the right side below the diaphragm. (See Figs. 40 and 49.) It daily secretes from the blood about three pounds of a bitter fluid, called *bile*. All of the dissolved nutrition absorbed into the blood from the digestive organs passes into the liver. Here the urea which is to be cast out by the kidneys originates, and here the albuminoids are decomposed. As one result of these activities the blood, as it leaves the liver, prepared to enter into the general circulation, has a higher temperature than in any other part of the body. While the intestines are resting, the bile is stored in a sack on the under side of the liver, called the *gall-bladder*, to be poured into the small intestine at time of digestion. The bile seems designed in part to act on the fatty foods, and in part to carry off certain impurities from the blood through the intestines. The **pancreas** is a long, flat gland, which lies across the spinal column, just back of the stomach. It weighs about one fourth of a pound. It is like the salivary glands in structure, and secretes into the intestine a fluid known as the *pancreatic juice*. This juice appears to be the chief agent in completing digestion after food has left the stomach.

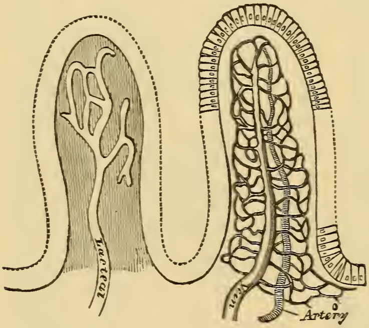


Fig. 43.

Villi, highly magnified, showing Lacteals and Blood Vessels.

No fat is ever found in the pancreas, and this organ corresponds with the edible "sweet bread" of domestic animals. (See Fig. 45.) These two fluids, pancreatic juice and bile, are different from gastric juice, for they are alkaline (like lye) instead of acid, and they act specially upon the heat-producing substances, such as fats, starches, and sugars. The small intestine absorbs more of the products of digestion than any other part of the alimentary canal. By the action of the bile and the pancreatic juice, the food in the intestine becomes changed into a milky substance, called *chyle*, which readily enters the blood. The length of time required for complete digestion varies with the different kinds of food, and with the conditions of the system.

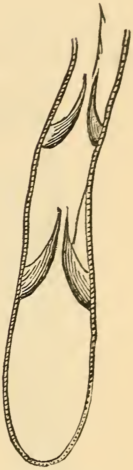


Fig. 44.

End of Lacteal, showing Wall and Valves, greatly enlarged.

The following is the length of time required for digesting some common articles of food: raw apples, two hours; boiled beans, two hours and thirty minutes; roasted beef, three hours; wheaten bread, three hours and thirty minutes; milk, two hours; roasted pork, five hours; boiled rice, one hour; boiled potatoes, three hours and thirty minutes.

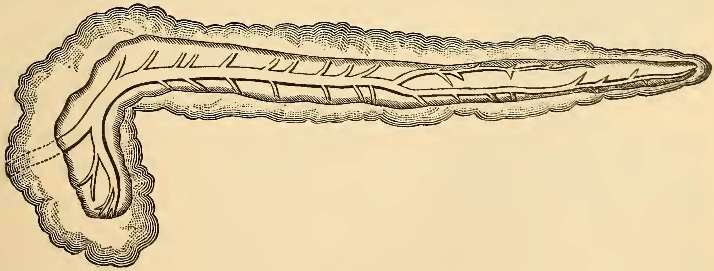


Fig. 45.

Section of Pancreas, cut to show the Pancreatic Duct

9. Intestinal absorption of food occurs in two ways: (1) As in the stomach, so here, the fluids enter the blood by passing directly through the inner coat of the intestine and the walls of the minute blood-vessels with which the mucous lining is densely filled. The nutrition thus absorbed by the blood-vessels, like that similarly taken up in the stomach, is carried by one great vein to the liver, by which it is fitted to enter the general circulation. (2) Other portions are taken up by minute tubes, which have their beginning in the villi of the lining coat, and which suck up nutrition, much as the rootlets of a plant suck up moisture, by the action of valves along their inner walls. These tubes are called **lacteals**, because the chyle that they draw from the intestines is milk-like in appearance. (See Figs. 43 and 44.)

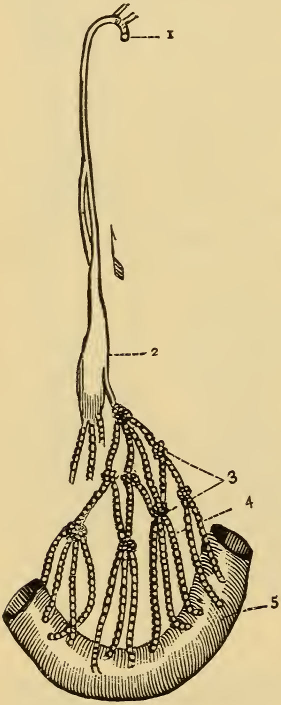


Fig. 46.

THORACIC DUCT AND LACTEALS.

1, mouth of thoracic duct; 2, lower end of duct; 3, mesenteric glands; 4, lacteals; 5, intestine.

The lacteals convey the nutrient products of digestion into the circulation in the following manner: The abdominal cavity is lined throughout, and the organs which it contains are coated by a velvety membrane which permits of easy motion of all the parts. By means of a double fold of this membrane, called the *mesentery*, the intestine in its several convolutions is suspended, and is fastened, along the line of the spinal column, to the wall of the cavity. The space between these folds of the mesentery is filled with a network of nerves, blood-vessels, and lacteals. (See Fig. 47.) As the lacteals of the myriad villi leave the intestine and pass through the mesenteric folds, they unite here and there into clusters called mesenteric glands. In these glands their burden of milky chyle undergoes changes by which it takes on more of the nature of blood. Leaving the glands, the lacteals are fewer in number but larger in size, and finally unite to form what is called the *thoracic duct.* (See Fig. 46.) This is a tube about eighteen inches long, and as large as a goose-quill. In it the changed chyle passes upward close to the spine, as far as the shoulder-blade, where the duct curves forward a little. Its contents are then drawn, by a sort of suction, into a large vein below the left collar-bone and near the heart. By these two methods of absorption, the nutrient parts of food enter the blood.

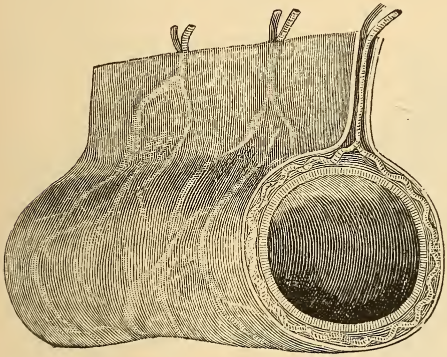


Fig. 47.

SECTION OF SMALL INTESTINE.

Showing three coats and blood-vessels. The doubled outer coat forms the mesentery in which the intestine is slung, and through which pass veins and lacteals.

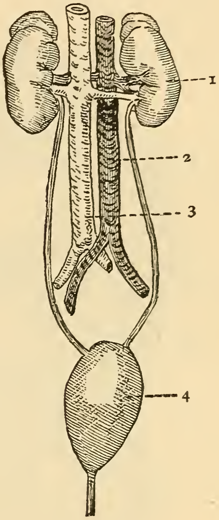


Fig. 48.

KIDNEYS AND THEIR VESSELS.

1, left kidney; 2, ascending vein; 3, aorta; 4, bladder.

10. There are certain organs especially designed to remove impurities from the body. These organs of excretion are the lungs, skin, colon, and kidneys. The lungs excrete much carbonic acid and watery vapor, with scarcely a trace of urea. The skin excretes much water and some salts, with very little carbonic acid. The colon excretes some waste secretions and unassimilable parts of food. The kidneys excrete much water, waste nitrogen, and salts, with but little carbonic acid.

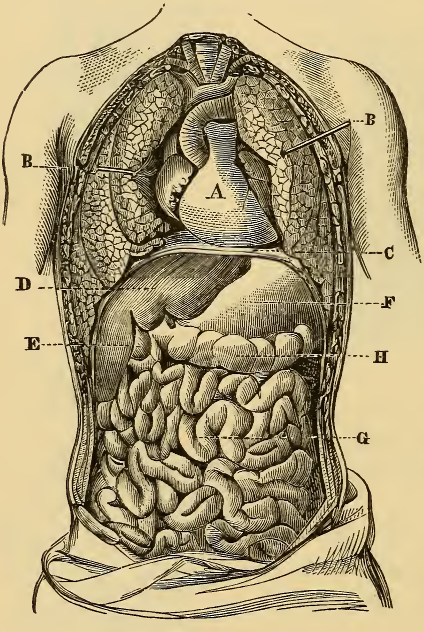


Fig. 49.

Relative Positions of the Chief Organs of the Trunk.

A, heart; *B*, lungs, drawn aside; *C*, diaphragm; *D*, liver ; *E*, gall bladder ; *F*, stomach ; *G*. small intestine ; *H*, large intestine. The kidneys are not shown.

The kidneys are two in number, situated in the back portion of the abdomen, one on each side of the spinal column, a short distance below the diaphragm. (See Fig. 48.) They are dark-colored, bean-shaped bodies, each about two thirds as large as the fist, and they are generally enclosed in fat. They are made of two kinds of vessels: (1) blood-vessels, (2) exit tubes. Large branches of a great artery, called the aorta, constantly convey a portion of the blood to the kidneys. This blood passes through the capillaries of the kidneys, and is collected into veins that return it to a larger vein that empties into the right side of the heart. As the blood goes through the capillaries, its watery part strains through their thin walls, carrying with it various salts and gases from the blood. The water and impurities pass out of the kidneys and collect in the bladder. (See Fig. 48.)

QUESTIONS.—1. What is the derivation of the word *digestion?* Does all of the food we eat enter into the structure of the body? Do the kidneys nourish the blood? What is the origin of the word *alimentary?* What is the alimentary canal? Describe its general structure. Its principal parts in their order. Is the liver a part of this canal?

2. Where does digestion begin? Have the upper teeth any motion? Describe the exterior parts of a tooth. The interior structure. What is the hardest substance contained in the body? Has a tooth life? Are all of its parts sensitive?

3. The bones of the head grow—do the teeth grow in the same way? How many more teeth has an adult than a young child? How many cusps have the eye-teeth? What is the technical name of these teeth? How many, and where, are the bicuspids? The molars? What teeth separate the cuspids of the left side from those of the right side? Why are they called *incisors?* What does *molar* mean?

4. The tongue has the sense of touch—how is this helpful in mastication? Can the skin taste anything? Does the tongue receive any taste from a drinking-glass? Why not? What does *parotid* mean? How many salivary glands are there on each side of the face? Name and locate them. What are some uses of the saliva?

5. What is the second step in digestion? Describe the pharynx. How many passages lead from it? Which of these is a food passage? Describe the muscular structure of the esophagus. Its position and course. What tube in front of the esophagus? Why does not food pass into the pipe?

6. What are the two great divisions of the trunk? What great muscle lies between the chest and the abdomen? Describe the shape of this muscle.

7. What opening at the lower extremity of the esophagus? Why is it so named? Into what organ does the cardiac orifice lead? What sort of muscle opens and closes this orifice? What other annular muscle has the stomach? What great gland lies to the right of the stomach? Describe the action of the stomach when food is received by it. What is gastric juice? Describe the structure of the stomach's middle [illegible]. The motions of the stomach. What class of foods is here taken [illegible] the circulation, and how? What is chyme? What does the stoma[illegible] with fats?

8. Describe the intestines. What are the villi? How do they act?

Where is the duodenum ? What juices aid the intestines in the digestion of fatty substances ? Where is bile produced ? Where is it stored up for use ? Why is the pancreas so named ? Is it a part of the digestive canal ? What are the situation and size of this organ ? What is chyle, and how is it produced ?

9. Give an outline of the two methods by which nutrition enters the circulation from the intestines ? Where do the intestinal blood-vessels lead to ? Describe the intestinal coats. What is the mesentery ? What mechanical use has it ? What does *lacteal* mean ? What do the lacteals convey into the blood ? Describe the process. What is the thorax ?

10. What general function have the skin and the intestines in common ? Name other organs of excretion. Where are the kidneys ? Describe them. What waste originating in the liver is cast out of the body from the kidneys ?

Name the principal vital organs above the diaphragm. Why are the intestines closely folded together ? Of what organ is the gall-bladder an adjunct ? Which is the higher, the liver, or the small intestine ? Can you think of any reason for this ?

CHAPTER VII.

HYGIENE OF DIGESTION.

Etymology of Terms.

ăn'tĭ dōte (Gr. *anti*, against ; *didonai*, to give).
ꞓon ġĕst'ed (Lat. *congerere*, to crowd together).
ꞓor rōde' (Lat. *corrodere*, to gnaw).
de ġĕn er ā'tion (Lat. *de*, away from; *genus*, natural condition).
dy̆̄s pĕp'si ȧ (Gr. *dus*, ill ; *pepsia*, digestion).
ĭn'du rate (Lat. *indurare*, to harden).
na̤u'se ȧ (Gr. *nausia*, sea-sickness).
sĕn'so ry (Lat. *sentire*, to perceive by the senses).

1. The health and vigor of the system depend in the greatest degree upon the efficiency with which the body is nourished ; hence the conditions that affect the process of digestion are very important.

The manner of eating needs to be such :

1. that the food shall be thoroughly chewed ;
2. that it shall not be taken with too much drink, since much water dilutes and weakens the digestive juices ;
3. that very cold or very hot articles shall be avoided, since they disturb the normal temperature of the stomach ;
4. that the food shall be eaten deliberately.

The nature of the diet is also a matter of importance, and is more or less to be determined by habits of life, by climate, and by some other conditions. The inhabitants of the polar regions live almost exclusively on fats ; some mountain tribes in central Asia live on flesh alone ; one third of the population of the globe lives chiefly on rice ; inhabitants of the torrid zone live principally on fruits. In a varied climate, such as that of the United States, and with people who lead active lives, it is best, as has been pointed out, that the diet should not be confined to one article. A few articles eaten together are usually better than a meal made of a single substance, because very few foods contain all the elements needed to nourish the whole body. Bread made of wheaten flour, or of the meal of other grains, eaten with ripe fruits, forms a safe combination of substances. Lean beef, eggs, and milk, served with grains, tubers, and fruits, are nutritious and wholesome. Flesh food is usually quite easily digested, and yields a ready supply of energy; it does not, however, serve the purposes of great endurance as fully as the grain foods do. The simpler and plainer the manner of cooking, the more fully are the requirements of nutrition attained. When foods are boiled together, or fried so that grease is thoroughly mixed with them, or seasoned with much salt and spices, they are less easily digested. Roasting and broiling usually prove to be the best methods of cooking meats.

The amount of food should be sufficient to restore the waste of the system, and to satisfy the appetite, if it be a natural one. Bread and fruit must be eaten in larger quantities than such substances as cheese, because they are not so concentrated. The amount of food required, as well as its kind, is much affected by exercise in the fresh air and sunshine. The active plowboy needs more than the quiet student, and the former may readily digest kinds of food that would prove quite indigestible to the latter. The quantity of food needed during crisp, freezing weather is much greater than that required in spring and summer.

2. The times of eating should be such that, after the organs have had opportunity to perform their work, they may have an equally long season for rest and repair. Three meals a day are sufficient for any healthy person, and a less number may be better for some. Regularity in eating is one of the most important of requirements, and eating between meals robs the organs of rest. Very late meals call upon the stomach for action during hours that are needed for repose. It is improper to pass immediately from hard work of muscle or brain to the table, for the system needs time to prepare for the change. It is equally injurious to engage in active labor of any kind just after eating, for the forces of the system are required for a time in beginning digestion.

The condition of the mind affects both appetite and digestion. Food eaten under peaceful and agreeable influences will receive the attention and energy of the digestive apparatus, while anger, sorrow, or any kind of excitement will render the forces of the stomach almost powerless.

3. The teeth require careful attention in order that they may be preserved in sound condition, and that they may, by their appearance, add to the beauty of the face. They should be closely watched, and as soon as a cavity is detected it should receive the attention of a dentist.

To cleanse the teeth a soft brush is best, since a harsh one is injurious to the protecting gums. To remove more effectually any deposit, employ pulverized chalk upon the brush. Even with this care, the saliva will in many cases deposit a crust of tartar about the edges of the gums, which needs to be removed, else it will injure the enamel, and cause the gums to recede. By attention to cleanliness and repair, the teeth may be preserved during life and the general health be greatly enhanced. The teeth are not only useful as digestive organs, but serve as important aids in the distinct articulation of sounds.

4. Dyspepsia is a name under which are included the principal disturbances of the functions of the stomach. Its more common symptoms are loss of appetite, heart-burn, and nausea. It is not, as a general rule, a painful disorder, and the causes underlying dyspepsia vary widely. Appetite for food in the healthy stomach shows itself in regularly recurring activity of the sensor nerves of the inner lining of this organ. Anything that deranges the mucous membrane either by inflammation, or by hardening of the coats (induration), or by corrosion, tends on the one hand to blunt, or on the other hand to excite too greatly the sensibility of these nerves, and in this and other ways produces dyspepsia.

Most condiments, and all stimulants, are hurtful to a normal stomach. Irregularity in the hours of labor and rest, of eating and sleeping, must in time make themselves felt in the form of dyspepsia. In cases of marked debility of the stomach, hot milk and hot water are often beneficial by raising the temperature and supplying food that is readily absorbed. Sometimes weak acids and artificially prepared pepsin are given. These furnish to the stomach a substitute for the gastric juice which it is unable to secrete. Every form of dyspepsia is an indication of some disease that is more easily avoided than cured.

5. Blood from the stomach and intestines passes, as we have seen, directly to the **liver.** If it has taken up injurious substances in the alimentary canal, where it should only take up nutrition, it is plain that the liver must be the next sufferer. This we find to be the fact. The habitual use of **alcoholic drinks** is especially injurious to this important organ. The liver becomes inflamed and congested, producing enlargement and fatty degeneration. In extreme cases it presents a shrunken appearance, and is bunched in places, producing what is called "hob-nailed" liver. When this gland is diseased, all its functions are necessarily impaired—the blood-vessels are obstructed, and bile is not properly secreted.

The activity of all the excretory organs is necessary to health. Diseases of the *kidneys* are of the most serious character. The use of alcohol tends to injure these organs.

The alcohol dilates the delicate cells of the kidneys, and may even *destroy these parts.*

6. The universal drink is water. It is an inorganic substance, compounded of the two elements—hydrogen and oxygen. Water quenches thirst, and fills the different parts of the system with their needed quantity of liquids. All substances added to water affect its purity and usefulness as drink. Of pure water, no one is usually disposed to drink too much. Water is easily excreted, and does not tend to inflame or irritate. Too little water causes thirst, which distresses us until it is relieved.

Dangers arise from the impurities contained in the water we drink. Water containing much of the mineral salts, such as lime, iron, or common salt, is unfit for use. Water having a bad odor or taste, or water that is colored, or water that will produce a scum when boiled, is unfit for use. Typhoid and malarial fevers are often caused by the use of impure water. (See p. 212.)

The following rules should be carefully observed:

Avoid shallow wells, and such as are near vaults and sewers.

Use no water that will produce a scum when boiled.

Protect cisterns and wells from inflow of surface water.

Use no water having a disagreeable odor or taste.

Filters remove bad odors and harmful substances from impure water, by bringing the water in contact with charcoal. The charcoal contained in most filters absorbs the impurities. Boiling drives off the gases and coagulates the organic impurities. Salts are taken from water by causing the water to pass off in the form of steam.

Much drink at meal time weakens digestion by diluting the juices of the stomach. If the food be eaten deliberately, there will be little demand for copious drinks of any kind. To drink hastily large quantities of any cold fluid, as ice-water, deranges digestion.

If substances that have a great attraction for water be taken into the body, they will draw the water from the various tissues. If the attraction be great enough, they will decompose the tissues. Substances that are called caustics destroy the flesh by their intense attraction for the water in the flesh. Common lye, lime, sulphuric acid, and carbolic acid destroy flesh in this way. Substances having a milder attraction for water do not destroy the tissues, but draw the free water from them. This causes the tissues to shrink, to harden, and to stiffen. Substances of this kind, taken either in solid or liquid form, produce thirst. Alcohol acts in this manner.

7. **Alcohol** in the strongest form, when taken into the mouth or stomach, will blister the mucous membrane, and decompose the structure of the parts, so great is its affinity for the water these contain. The fermented and distilled drinks are dilute alcohol. If these are used, the same kind of action occurs in less degree of violence. Thirst is produced by the drinking of any liquor containing alcohol. Examinations show that the tissues of those who are addicted to the use of alcoholic beverages are hardened by the loss of water. This process is called *induration.* This is especially true of the nervous tissue of those who die from the effects of alcohol.

The digestive fluids are the chief agents in preparing food for the use of the tissues. Alcohol tends to hinder the digestion of food, and to retard the dissolving of the albuminoids. By its action on the nerves and muscles of the stomach, the operations of this organ are less vigorous.

As already stated, the use of alcoholic liquors tends to inflame the delicate membrane that lines the stomach. This membrane is marvelously full of tiny blood-vessels. Alcohol causes these capillaries to dilate so that they become engorged with blood, and makes the gastric juices flow in excess.

8. Medical writers, without exception, designate **tobacco** as a poison. When it is taken into the mouth its poisonous properties are absorbed by the lining membrane and enter the blood. When thus absorbed into the blood, it produces nausea, vomiting, fainting, and cold sweats. If it is smoked instead of chewed, the same results follow. When the tobacco is chewed, its hurtful properties are swallowed with the saliva. In this way the muscles and nerves of the stomach are so greatly injured that this important organ of digestion becomes weak and loses its tone. So powerful is the poison of tobacco that children have been killed by its application to the head in diseases of the scalp. In medical practice it is used only in lock-jaw and a few other dangerous diseases.

Opium in its various forms acts directly upon the nerves. A small dose quiets pain and a larger dose soothes one to sleep. It arouses the brain and fires the imagination. It matters little in what form opium is taken, whether solid as in pills, liquid as in laudanum, or in the form of vapor, its effects are always the same. The reaction from this unnatural excitant is very depressing, and tempts one to a renewal of the stimulus, till, step by step, a man gradually acquires the so-called opium habit, which it is almost impossible to throw off, and which makes of him a total wreck, both physical and mental.

Even when a man has sufficient determination to throw off the habit when once acquired, it takes a long time for the system to recover from the shock. The digestion is impaired, the appetite is weakened, the muscles waste, the skin shrivels, and the nervous centers are paralyzed.

Poisons sometimes so closely resemble articles in common use that all dangerous substances should be plainly marked, and all unknown substances should be destroyed. When healthy persons are suddenly taken severely ill soon after swallowing some substance, it is probable that it is a result of poison. In cases of poisoning, empty the stomach promptly. This may be done by drinking a cup or two of warm water, in which has been stirred a tablespoonful of ground mustard or common salt. Besides emptying the stomach, the effects of the poison may be counteracted by the action of some substance of a different nature. A list of the more common poisons which are likely to be taken accidentally is given below, with some of their antidotes to be used in cases of emergency, when a physician is not at hand and no time is to be lost.

The acids most likely to be used as poisons are *muriatic*, *nitric*, and *sulphuric*. These acids, if swallowed, destroy the mucous membrane of the stomach, and, in sufficient quantities, they will corrode the entire walls of the alimentary canal. The *antidotes* are the various alkalies, such as strong soap-suds, chalk, saleratus in water, and lime-water.

The alkalies most likely to be used as poisons are *ammonia*, and some forms of *potassa*. These substances burn the walls of the alimentary canal. The *antidotes* are the vegetable acids, given in dilute form, such as weak vinegar, or tartaric acid dissolved in water. Oils, such as castor oil, linseed oil, sweet oil, or cream, may be used as antidotes of alkaline poisons. Vomiting should afterward be provoked.

Common *arsenic*, in any of its forms, such as *white arsenic*, *Fowler's solution*, or *Paris green*, is a deadly poison. To relieve it, cause vomiting by the use of mustard or ipecac. The *antidote* is the hydrated peroxide of iron. Use lime-water if Fowler's solution has been taken.

Sugar of lead (acetate of lead) and *white lead* are poisons. Besides vomiting, use Epsom salt as an *antidote*.

Any of the *mercurial preparations* are poisonous. Use white of eggs and milk as *antidotes*.

The most common **narcotic poisons** are *alcohol*, *opium*, *aconite*, *belladonna*, *hemlock*, *digitalis*, *tobacco*, *nux vomica*, and *strychnine*. Empty the stomach by using mustard or alum.

Give strong coffee. Keep the sufferer in motion as much as possible. In cases of poisoning by *nux vomica* and *strychnine* allay spasms by the use of chloroform.

QUESTIONS.—1. What effect has nourishment upon the general system? How much of the digestive process is under the control of the will? How may the voluntary acts of digestion aid the involuntary processes? Give some simple rules as to the manner of eating. What sort of diet is best for people living in our country? What are tubers? Which is the better way of cooking meats—broiling, or frying? How is the kind of food required dependent upon the climate? How can we determine the amount of food to take?

2. If the stomach is overloaded the diaphragm is crowded upward—what must be the result of this on the heart and lungs (see Fig. 49)? What is "concentrated food"? Give some simple rules as to times of eating. The stomach nerves lead to the brain—should both brain and stomach be excited at the same time? Show how excitement at the time of eating tends to hinder digestion.

3. What organs of digestion come first into play when you eat? How do the teeth differ from the true bones in respect to repair? Growth? Exposure? What care do they, therefore, need? What special use, other than in mastication, have they?

4. What is the literal meaning of the word *dyspepsia?* Is dyspepsia a disease? How does the appetite for food make itself felt? Of what substances does the gastric juice mainly consist? What remedy does this suggest for some cases of dyspepsia? What effect do condiments and stimulants have on the stomach? State some of the common causes of dyspepsia.

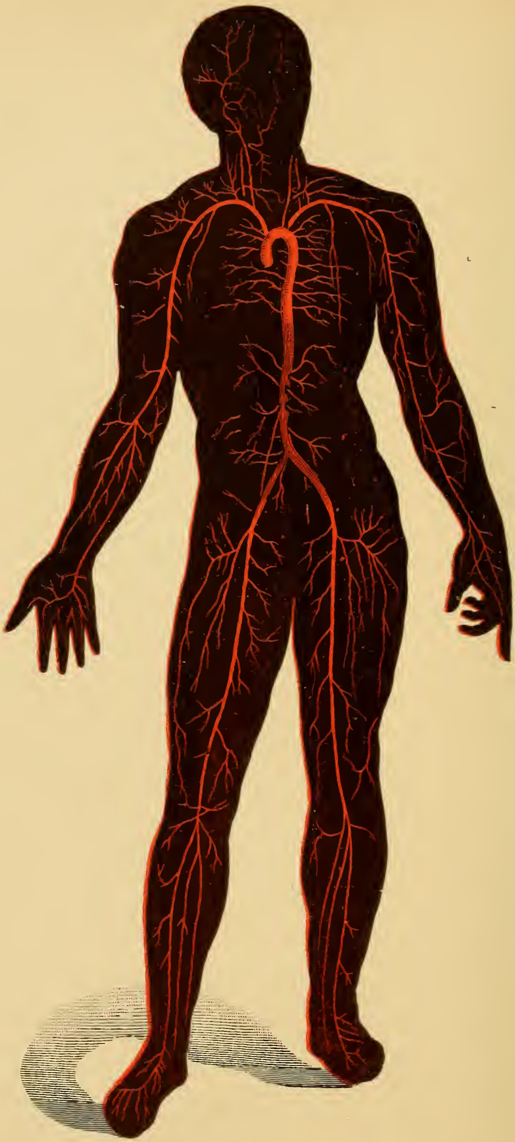
5. Does the blood that is taken up from the digestive canal pass at once into the circulation? In what part of the body has blood the highest temperature? In what organ does this fact indicate great chemical activity? What are some of the effects of alcohol upon the liver? Upon the kidneys?

6. What is the most important of all food substances? What proportion of our bodies consists of water? Of what elements does pure water consist? Give some simple precautionary rules in respect to drinking water. What is a filter? What are the usual consequences of too much water taken at meal-time?

7. What is thirst? What liquid best allays it? What liquid especially

arouses it, and why? What is the first effect of alcohol upon the stomach? What does *induration* mean? How does alcohol harden animal tissues? What class of food substances is the most useful in building up these tissues (Chapter V.)? What class of foods, therefore, does alcohol render especially indigestible? Is the gastric juice alkaline or acid? What is "acidity of the stomach"? May it be provoked by alcohol?

8. Is tobacco a poison? Name some effects of the use of it. What are the evils attendant upon the use of opium even in small doses? What is the origin of the word *antidote?* Name the two principal classes of poisons. For which class should we take alkaline antidotes? Acid antidotes? Oily antidotes? Whereabouts in the digestive canal do alkalies and fats combine and correct each other?



The Arterial System.

CHAPTER VIII.

CIRCULATION.

Etymology of Terms.

ā ôr'tȧ (Gr. *aeirein,* to raise).
är'ter y (Gr. *arteria,* windpipe. The ancients believed that arteries were air passages).
a̤u'ri ꞓle (Lat. *auricula,* little ear).
ꞓō ăg'ū lāte (Lat. *cogere,* to drive together).
hĕm'or rhaġe (Gr. *aima,* blood; *rhegnunai,* to burst).
lȳm phăt'iꞓ (Lat. *lympha*), conveying lymph.
pĕr i ꞓär'di um (Gr. *peri,* around; *kardia,* the heart.)
pōrt'al (Lat. *porta,* a gate), the gateway of the liver.
pŭl'mo na ry (Lat. *pulmo,* the lung).
vĕn'tri ꞓle (Lat. *ventriculus,* stomach).

1. The nourishment prepared by the alimentary canal is carried in the blood to every part of the body. This process is called the **circulation.**

In every living thing there is a fluid that is constantly moving through the entire body. In plants this circulating fluid is the sap. In all the higher animals, including man, it is a warm, red liquid, called blood.

The General Plan of Circulation.—The heart, like a tiny engine, forces the blood through long branching tubes that lead to every portion of the body. The blood then returns by running into other tubes, which empty into one another as do the tributaries of a river, and which finally pour the blood into the heart again in a continuous stream. (See Fig. 56.)

In the circulation through the body some very important changes occur in the blood:

1. In passing through the inner coats of the alimentary canal, it gains food.

2. In feeding the tissues, it loses its nutritious elements.

3. In passing over the worn-out particles in the body, the blood becomes impure by absorbing them.

4. At other places, the blood is purified by having this waste matter removed.

By these changes, the blood fulfills its great purposes. It *nourishes* the parts, it *purifies* them, and it *warms* them.

2. Composition of the Blood.—The blood is of a deep red color, and is somewhat thicker than water. It has a smooth quality, which causes it to flow very freely, and a faint odor peculiar to the animal from which it is taken. It constitutes one twelfth the weight of the body. When the blood is examined by aid of the microscope, it is found to consist of two parts: (1) Of vast numbers of minute bodies of circular form, called *corpuscles* (little bodies); and (2) of the fluid part, called the *plasma*. The plasma is the greater portion of the blood. It carries the corpuscles and the food particles, as the water of a stream carries the multitudes of fishes and the tiny particles of solid matter that are in it.

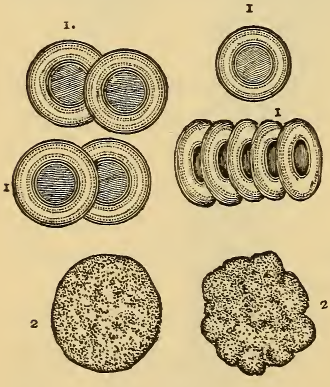


Fig. 51.

CORPUSCLES.

1, colored; 2, colorless.

The corpuscles are far too small to be seen without the aid of a microscope. Most of the corpuscles have a reddish hue, and give color to the blood, but some of them are colorless. The colored corpuscles are disk-like, while the colorless ones are of a great variety of shapes. (See Fig. 51.) They are about $\frac{1}{3500}$ of an inch in diameter across the disk, and one fourth as much in thickness, being thinnest in the middle. The colorless corpuscles are fewest in number, and are larger than the colored. To see the corpuscles, place a drop of freshly drawn blood on a clean microscope slide; lay on a piece of thin glass, to spread the drop, and put the slide under a powerful object-glass. The corpuscles may be seen moving about in the plasma. They appear to be of use in carrying the gases of the blood to and from the lungs.

The plasma of the blood is a complex fluid. It is composed of two parts: (1) The greater portion is a clear, straw-colored liquid, called *serum;* and (2) it contains a small amount of *fibrin* in solution. This fibrin of the plasma is a peculiar substance, resembling the fibrin of lean meat and the gluten of flour.

When blood is exposed to the air, it separates into two parts—the clot and the serum. This separation is caused by the *coagulation*, or clotting, of the fibrin. By this process the fibrin of the blood changes from its soluble or fluid form, to a stringy, tough mass. As the fibrin becomes solid, its fibers entangle the corpuscles, and strain them out of the serum, leaving the latter quite clear. The corpuscles and the fibrin form the clot. Coagulation is the great safeguard against bleeding to death from hemorrhage of the nose or lungs, because it tends to thicken the blood and to form a coating over the broken vessels so as to stop the flow of blood.

The following outline shows the composition of the blood:

Blood..	corpuscles...	colored.......	clot of coagulated blood
		colorless	
	plasma......	fibrin.........	
		albumen.	
		serum	water
			salts
			soluble food

3. The organs of circulation are the *heart*, *arteries*, *capillaries*, and *veins*.

The heart is a double muscular organ, about the size of the fist, and situated in the middle of the chest, between the lungs. It is enclosed in a loose sac of connective tissue. called the *pericardium*. This sac is moistened by a watery secretion, which diminishes the friction between the heart and the pericardium. The heart is supported by the diaphragm, and by the great tubes that are connected with it. It is a hollow muscle, consisting of four cavities, with their walls and passages. There are two of these cavities on each side of an unbroken partition which divides the heart into a right and a left side. The cavities are called *auricles* and *ventricles*. One auricle and one ventricle are on each side of the dividing wall, and the auricles are slightly smaller

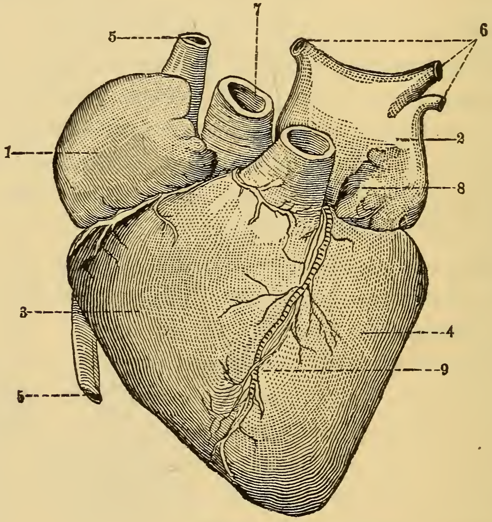


Fig. 52.

External View of the Heart as seen from the Front.

1, right auricle; 2, left auricle; 3, right ventricle; 4, left ventricle; 5, systemic veins; 6, pulmonary veins; 7, aorta; 8, pulmonary artery; 9, coronary vein and artery.

than the ventricles. The auricles are the upper cavities, and the ventricles, the lower. By this arrangement there are two auricles and two ventricles; viz., a right and a left auricle, and a right and a left ventricle. In Fig. 52, we have a front view of the heart, about one half of its natural size.

The passages of the heart are of three sets, as follows:

1. There are openings into the auricles, so that the blood may flow *into the heart.*
2. There are openings at the bottom of the auricles, by which the blood passes down *into the ventricles.*
3. There are openings from the ventricles, through which the blood flows *out of the heart.*

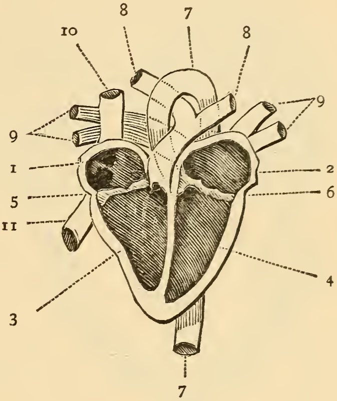


Fig. 53.

Diagram of Passages of the Heart.

1, right auricle; 2, left auricle; 3, right ventricle; 4, left ventricle; 5, tricuspid valve; 6, mitral valve; 7, aorta; 8, pulmonary artery; 9, pulmonary veins; 10, vena cava (upper); 11, vena cava (lower).

The openings into the auricles are constantly open, so that the blood may flow in at all times; the openings from the auricles into the ventricles are alternately opened and shut by door-like valves, which swing apart to let the blood pass down from the auricles into the ventricles, but which close again to prevent it from passing back; the openings from the ventricles are guarded by semi-circular folds, which permit the blood to be forced out of the ventricles into the large tubes leading from the heart, but close promptly to stop it from running back into the heart when the ventricles expand to be filled again. By this arrangement, the blood enters the auricles of the heart in two constant streams, and is thrown out in two opposite streams from its ventricles. (See Fig. 53.)

4. The Valves of the Heart.—The passage of blood from auricle to ventricle, and from ventricle to artery in each of the halves of the heart is regulated by valves, which are so arranged that while one set is open the other set is closed, and so that the blood can flow in but one direction.

The right auricle pours its blood into the right ventricle through a valve which has three triangular cusps or points, and which is therefore called the *tricuspid valve.* When the right ventricle contracts to force its venous blood out through the pulmonary artery to the lungs, the tricuspid valve is crowded upward and closed by the pressure of the blood below it. (See Fig. 54.) Tendons attached to the muscular walls of the ventricle prevent this pressure from pushing the tricuspid valve through into the auricle.

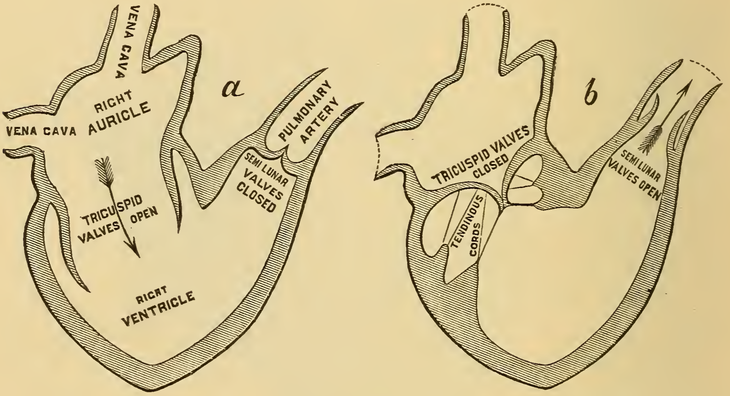


Fig. 54.

Valvular Action of Right Side of Heart.

a, ingress of venous blood ; *b*, expulsion of same to the lungs.

The same contraction of the right ventricle forces open an orifice which leads into the pulmonary artery. This orifice is guarded by a valve which has three pockets arranged in a circle, so that their edges meet all around when the valve is closed. (See Fig. 55 (2).) Each of these pockets is fixed upon one of its borders, and free upon the other. Because of their half-moon shape, these valves are called the *semi-lunar valves*. Another semi-lunar valve opens outward from the left ventricle.

Corresponding with the tricuspid valve of the right side of the heart is one which separates the left auricle from the left ventricle. This valve, however, has but two cusps instead of three. From its resemblance to the double peaks of a bishop's miter, it is known as the *mitral valve*.

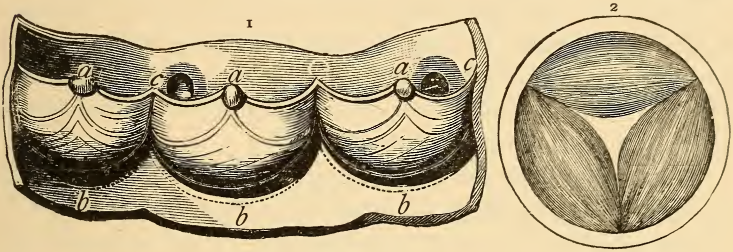


Fig. 55.

Valves of the Heart.

1. Semi-lunar valves, open. *a*, free border ; *b*, attached border ; *c*, arterial openings. 2. Semi-lunar valves, partially closed.

The openings through which blood from the body pours into the auricles of the heart are not guarded by valves, since the auricles do not need to contract with much force to pass their blood downward into the ventricles, and no backward flow from the auricles is to be guarded against.

5. **The heart's action** is as follows : The blood streams into both auricles until they are full, the right auricle being filled by the returning blood from the system, and the left by pure blood from the lungs. The valves at the bottom of the auricles open at the same instant, and each ventricle is immediately filled by the blood from the auricle above it. The ventricles at once contract with great power, by which movement the valves of the auricles above are instantly closed, and the blood within the ventricles is

pushed with great force into passages leading away from the heart.

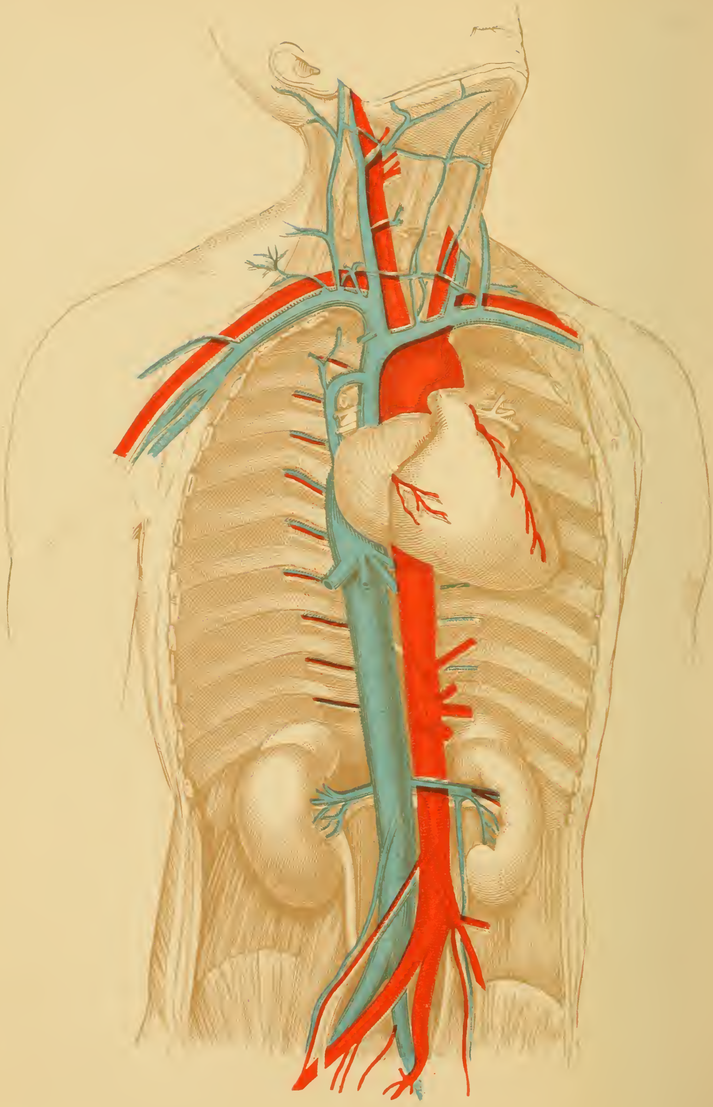
The left ventricle forces its contents into a great tube, called the *aorta*, which leads to all parts of the body. The right ventricle forces its blood into another tube, called the *pulmonary artery*, leading to the lungs.

While the ventricles have been contracting, the auricles have again filled, so that, as the ventricles relax, they in turn are refilled, and immediately repeat their former action. In this manner they alternately contract and relax, work and rest, during the whole of life.

This action is called the beating of the heart. The frequency of the beating is tested by feeling the heart as it strikes against the chest, or by hearing the beats which are caused by the closing of the valves.

There are two kinds of sounds: (1) a sound longer in duration, and lower in pitch, heard over the ventricles; (2) a shorter, sharper sound, heard most plainly over the base of the heart. It is thought that the first sounds are caused by the sudden closing of the valves between the ventricles and auricles; and the second, by the closing of the semi-lunar valves at the entrance to the large arteries.

Expert physicians can determine much about the condition of the heart by the character of the sounds. At each contraction of the ventricles, the arteries receive more blood than can be instantly disposed of. If the fingers are placed lightly on the artery at the wrist, the beating, or pulse, may be counted. Under ordinary circumstances, the heart contracts about seventy-two times in a minute. The causes that produce more rapid beating are exercise, warmth, rich food, stimulating drinks, and excitement. In fever the heart beats rapidly. As one grows feeble from any cause, the beating usually grows more rapid, but less powerful. When awake, the pulse is considerably faster than while asleep, and in standing, it is more rapid than while reclin-



ing. The time occupied in contraction is less than two thirds of the whole interval of one beat, so that the muscles of the heart rest more than one third the time. Although the intervals of rest thus gained are extremely short, they aggregate more than eight hours daily.

6. The tubes that conduct the blood away from the heart are called **arteries.** They subdivide into a vast number of small branches, so as to convey the blood to every part of the system. The **pulmonary artery** receives the blood from the *right ventricle*, and distributes it in the lungs to be purified. The **aorta** is the largest of the arteries, being nearly an inch in diameter. It receives the purified blood from the *left ventricle* and supplies it to the tissues of the body for their nourishment. The arteries are formed of a very tough, elastic substance, and, when empty, resemble rubber tubes. They have a smooth lining, and are comparatively straight, so as not to lessen the force given to the blood by the heart. They are placed near the bones, and pass beneath the great muscles, in order that they may be shielded from injury. When they are cut there is great danger of bleeding to death. The blood in the arteries flows in jets, because of the beating of the heart. With the exception of the semilunar valves at the heart, there are no valves in the arterial system. In Fig. 57, we see a portion of a large artery with branches from it. In the lower part of the figure, the artery is represented as cut open, to show the absence of valves.

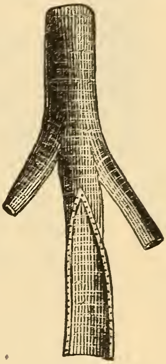


Fig. 57.

Portion of an Artery.

7. The minute, hair-like tubes, into which the arteries finally divide, are called **capillaries.** (See Fig. 58.) They are so extremely small (about $\frac{1}{3000}$ of an inch in diameter) that they are visible only by the aid of the microscope. The cutis is so full of these tiny vessels that the point of a needle can not enter it without breaking some of them so that the blood flows out. All parts of the body are, in like manner, full of them. Especially important capillaries are those of the lungs, in which venous blood is changed to arterial. The walls of all capillaries are extremely thin—so very thin that the serum of the blood readily passes through these coats and bathes the various tissues in which the capillaries lie. It is in this way that the nourishment contained in the blood comes in contact with the portions that need it. The corpuscles do not pass through the coats of the capillaries, but are carried along within these minute tubes.

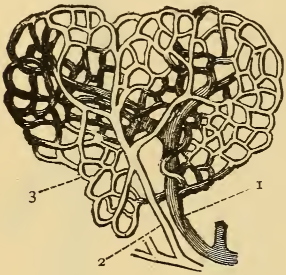


Fig. 58.

CAPILLARIES.

1, vein; 2, artery; 3, capillary.

The capillaries form in every inch of the body a microscopic network in which the arteries end and the veins begin. The circulation of the blood through the capillaries may be studied by the aid of powerful lenses in some thin and translucent animal membranes, such as the wing of a bat, or the foot of a frog.

8. **The veins** begin in the capillaries, where the arteries end. By uniting into larger and larger tubes, the veins conduct the blood back to the heart. The **pulmonary vein** pours pure blood from the lungs into the left auricle. It is formed by the union of four branches, two from each lung. The returning blood from the system is poured into the right auricle through the two largest veins in the body, called **venæ cavæ**, "hollow veins." One of these brings blood to the heart from above; the other, from below. The walls of the veins are thin and are formed chiefly of muscle. On the inner surface of most of the veins,

there are many folds, which serve as valves, and which permit the blood to flow only toward the heart. There are no valves in the venæ cavæ, or in the pulmonary and portal veins. Fig. 59 represents a portion of a vein, laid open so that we may see the valves.

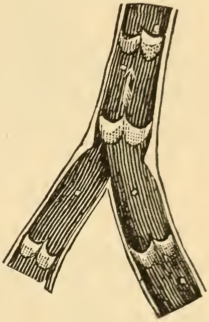


Fig. 59.

Portion of Vein.

The veins are usually nearer the surface than the arteries are, excepting the large veins, which are located deep in the body. These are larger than the arteries, and more crooked. The blood flows through them in a gentle, regular current. Both arteries and veins are larger near the center of the circulatory system than they are anywhere else. Heart, arteries, capillaries, and veins constitute a continuous system of closed tubes.

9. Course of the Blood.—If we could watch a drop of blood as it circulates in our bodies, this would be seen to be its course :

1. Laden with waste, it enters the heart at the opening into the right auricle.

2. It passes through the tricuspid valve into the right ventricle.

3. It is forced out by muscular contraction through the semi-lunar valves into the pulmonary artery, which divides into two parts, one part going to each lung.

4. It circulates through the lace-like capillaries of the lungs, throwing off its waste and taking up oxygen, and returns to the left auricle by way of the four pulmonary veins, two from each lung.

5. It passes through the mitral valve into the left ventricle.

6. It is forced out through the semi-lunar valves into the aorta.

7. It circulates through the capillaries of the system.

8. By way of the veins, it comes again to the right auricle of the heart.

This is the general course of the circulation, but on reference to the diagram, Fig. 60, it will appear that there is something to be added.

Among the branches given off by the aorta to the lower part of the body, two deserve special mention.

First, there is a large branch carrying blood to the stomach, intestines, etc. This branch, like other branches of the aorta, divides into small arteries, and these into capillaries, which form at last a large vein called the **portal vein.** This vein does not lead directly to the vena cava, but enters the liver, where it divides into smaller veins and capillaries. These capillaries gather into veins which form the **hepatic vein**, and this vein opens into the *vena cava.*

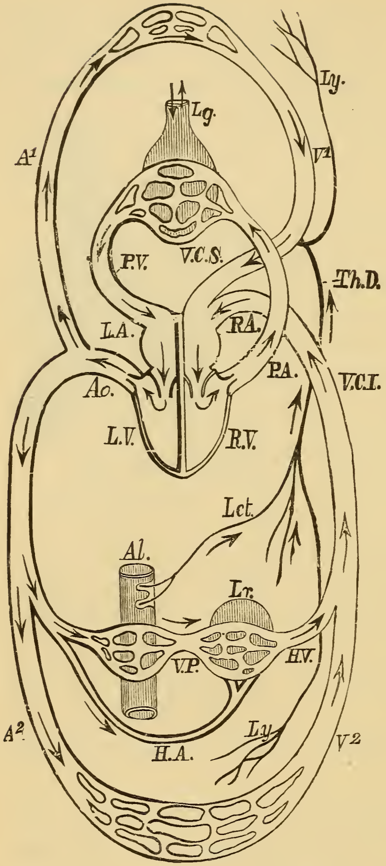


Fig. 60.

DIAGRAM OF THE COURSE OF THE BLOOD.

L.A., left auricle; *L.V.*, left ventricle; *Ao.*, aorta; A_1, arteries to the upper part of the body; A_2, arteries to the lower part; *H.A.*, hepatic artery; V_1, veins of the upper part of the body; V_2, veins of the lower part; *V.P.*, portal vein; *H.V.*, hepatic vein; *V.C.I.*, inferior or lower vena cava; *V.C.S.*, superior or upper vena cava; *R.A.*, right auricle; *R.V.*, right ventricle; *P.A.*, pulmonary artery; *Lg.*, lung; *P.V.*, pulmonary vein; *Lct.*, lacteals; *Ly.*, lymphatics; *Th.D.*, thoracic duct; *Al.*, alimentary canal; *Lr.*, liver.

Second, another branch of the aorta, called the **hepatic artery,** goes straight to the liver ; there it breaks up into small arteries and capillaries which mingle with those of the *portal vein*, and form one system, out of which the *hepatic veins* spring. (See Fig. 60.)

In Fig. 60 the dark portion represents the vessels that carry arterial blood, and the light, those which carry venous blood. By following the course of the arrows, the pupil may readily trace the circulation from any point in the diagram back to the same point.

The blood passes from the heart to the lungs, to be purified by the air that is breathed. By this means the blood loses its gaseous impurities and some water, and gains a supply of new gases to be carried to the system. This is called the **pulmonary circulation.** Every drop of blood must pass through the lungs and return to the heart before it is sent out to nourish and purify the tissues.

The pure blood is distributed to the entire body by the aorta and its branches, after which it returns to the heart. This is called the **systemic circulation.**

We have learned that the blood that returns from the alimentary canal passes through the liver before reaching the heart. This is called the **portal circulation.**

In a strict sense, the term *circulation* can only be applied to a complete circuit of the blood. If we follow the course of the blood in the pulmonary artery until its return *to the same place*, we shall find that its circuit has included both pulmonary and systemic circulations.

10. It will assist in the understanding of the processes of the circulation, to fix in the mind the following important points :

1. The right side of the heart is separated from the left side by a muscular partition through which there is no opening.

2. The right side of the heart receives and sends forth dark venous blood only ; the left side of the heart, red arterial blood only.

3. All passages leading *out* of the heart are *arteries;* all passages leading *into* the heart are *veins.*

4. Only one artery carries venous blood, namely, the pulmonary artery leading from the heart to the lungs.

5. The blood always leaves the heart through arteries leading out of the ventricles; it always enters the heart through veins leading into the auricles.

6. The semi-lunar valves open away from the heart; the tricuspid and mitral valves open downward from the auricles to the ventricles.

7. Arterial blood reaches the extremities through four great branches of the aorta (see Fig. 50); venous blood returns to the heart through veins that unite (*a*) from above in the *upper vena cava*, and (*b*) from below in the *lower vena cava.*

11. It is by the passage of the serum through the walls of the systemic capillaries that nutriment is brought to the growing cells of every tissue. How each kind of tissue takes from the blood the particular kind of matter that it needs for growth and repair, we do not know. It is true, however, that bone takes just such substances as are needed to make bone, and the muscles, cartilages, and nerves select what is necessary for them. Neither do we know how each tissue uses its proper nourishment for growth, and to repair waste.

This intricate and unknowable process of nourishment is called **assimilation.** Assimilation is evidently the crowning purpose of both digestion and circulation. Assimilation takes place most rapidly during rest, especially during the unbroken quiet of sound sleep.

Not only does the blood nourish the tissues, as just stated, but it is as much the purpose of the blood to **remove the waste matter.** The blood changes the worn-out particles to a soluble form, and absorbs them into itself as it flows through the tissues, finally removing them from the blood.

Gains and Losses by the Blood.—The blood is constantly losing some of its parts. In passing through the lungs, it loses carbonic acid and water; in the kidneys, it loses water, urea, and salts; in the skin, it loses water, carbonic acid, and salts; in the liver, it loses bile and other substances; by the repair of the tissues, it loses nutritious matter; by oxidation, it loses carbon and oxygen; by radiation, it loses heat.

The blood is constantly gaining, as follows: In the lungs, it gains oxygen; in the skin, oxygen; in the liver, sugar and other substances; from passing through the tissues, it gains impurities; from oxidation of food, it gains impurities; by oxidation, it gains heat.

The blood loses substances that are taken from it by the glands for secretions.

The blood gains nutritious substance from the digestion of food.

The fluid that passes out of the systemic capillaries into the surrounding parts returns to the veins by two methods of absorption: (1) much of it returns by being reabsorbed through the walls of the capillaries and minute

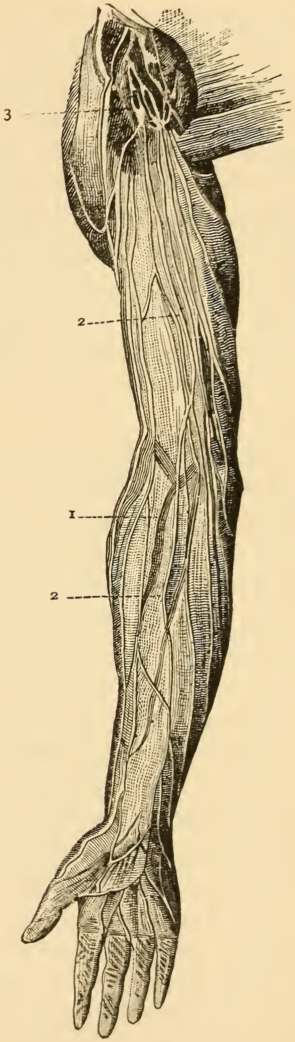


Fig. 61.

Superficial Lymphatics of the Right Arm.

1, vein; 2, lymphatic tubes; 3, lymphatic glands.

veins; but (2) there are special tubes for absorbing this fluid. called **lymphatics.** The lymphatics have their outer ends in almost all parts of the system, and by leading toward the heart they unite, and finally pour their contents into the large veins. (See Fig. 61.) These tubes are of extreme delicacy of structure, so that absorption readily takes place through their coats. They have valves in them which permit their contents to flow only toward the heart. Fig. 44 represents the end of a lymphatic, as it does the end of a lacteal. In time of hunger and starvation, the lymphatics suck up the fatty portions, and enable the individual to live for a long time on his own flesh and fat.

In recent years, there have occurred cases of remarkable fasting, in which men have lived without solid food for forty days or more. Such men have drunk water to maintain the fluidity of the blood, while they have lost in weight at the rate of a pound (more or less) per day by absorption. They lived upon their own tissues during the time of their fasting. The *lacteals* that have their origin in the lining coat of the intestines are lymphatics that carry nutrition into the blood.

12. Hygiene of the Circulation.—The body is designed to be active. Proper *exercise* of its parts is favorable to proper circulation of the blood. The muscles, in contracting, press on the veins and force the blood toward the heart, while the relaxation of the muscles permits the veins to fill again from the capillaries. Exercise makes the heart beat faster, and quickens the whole circulation.

Exercise increases the demand for *nourishment*. More food is needed, the appetite is sharpened, and the digestion is improved. The more thorough the flow of blood through the tissues, the more perfectly is waste matter removed from the body. Hence, proper exercise promotes assimilation, and hastens the removal of waste material. These two processes, when fully performed, are the very essence of health and vigor.

Exposure to *sunlight and fresh air* also enlivens the flow of blood, and improves its quality. Close-fitting garments, especially tight bands about the waist, neck, and extremities, hinder the flow of blood.

The circulation is often seriously interrupted by sudden changes to cold temperature, or by exposure of some part of the body to a draught of air. The circulation may be retarded by getting the clothing wet, or by sudden cooling after exercise. Such changes in the circulation tend to cause chill and to produce inflammation, resulting in a cold.

When blood-vessels are cut, the flow of blood may be stopped by pressure. This may be made with the thumb, or with a knotted handkerchief bound around the limb, so that the knot rests over the vein or artery; after tying the ends, twist the handkerchief tightly. If an artery is cut, the blood will flow in jets of a bright red color. In such a case, pressure should be made between the wound and the heart. If a vein is cut, the blood will flow regularly, and will be dark red, in which case pressure should be made at or beyond the cut. If the bleeding is moderate, bathe the wound freely with cold water, place the edges of the parts together naturally, and retain them in this position with strips of sticking-plaster and light bandages. Keep the wound quiet, that it may heal. Avoid salves and ointments. (See p. 224.)

Fainting is caused by want of blood in the brain. Place the patient in a horizontal position, with the head low. More blood will then flow to the brain, and the fainting will be relieved. If too much blood flows to the brain, dizziness and headache may result. Moderate exercise of the muscles will tend to relieve it, by drawing the blood to the muscles and heart. If headache results from impurity of the blood, exercise is again the remedy, by increasing the action of the lungs and thus more thoroughly aërating the blood. (See p. 225.)

13. Effects of Alcohol on the Circulation.—The body is kept warm by the union of the oxygen we breathe with certain substances in the blood. This kind of burning produces carbonic acid. If there is much heat produced, there is much carbonic acid formed. If oxygen were to act on alcohol as it does on other substances in the blood, much warmth would result, and much carbonic acid would be thrown off. The facts are, however, that alcohol undergoes little or no change in its passage through the circulation and the tissues, and the quantity of carbonic acid exhaled from the lungs of a man under the influence of alcohol is less than the amount from the same lungs when there is no alcohol in the system. The temperature of the body is lowered, rather than raised, by the action of alcohol.

The action of the heart and blood-vessels, as of other organs, is regulated by a set of nerves called *the inhibitory nerves*. In their normal condition these nerves prevent the heart from beating too rapidly, and keep the blood-vessels from undue expansion. The paralysis of these nerves is among the first effects of the drinking of alcoholic liquors. Their restraining power being thus suspended, the rapidity of the heart-beat is increased, the blood-vessels are relaxed, and too much blood is sent through them; these, in turn, because their inhibitory nerves are paralyzed, offer little or no resistance to the incoming current of warm blood, and too much blood is received in a given time, especially at the surface of the body. The temporary sensation of warmth produced in this manner is rapidly followed by a decrease in temperature, because this large amount of blood at the surface is quickly cooled.

The presence of alcohol in the blood *injures the blood itself*. Alcohol combines with the water in the blood, as elsewhere, and so causes the corpuscles to shrink, and to become wrinkled and ragged. As a consequence, the corpuscles cannot so well carry oxygen to the tissues, or bear away carbonic acid from the system. The fibrin of the blood is injuriously affected by alcohol. The blood of those who are addicted to the use of alcoholic liquors does not coagulate naturally. Surgeons are unwilling to perform severe operations on habitual drinkers of alcoholic liquors, because their wounds will not heal like those of temperate persons. Those who use alcoholic liquors are less able to withstand hardship, and more liable to disease in case of epidemics.

The use of **tobacco** is especially injurious to the heart, giving rise to what is known among physicians as "*smoker's heart*."

QUESTIONS.—1. How does nourishment pass from the digestive organs throughout the system? What name is given to this movement of the blood? Give an outline of the circulation. Does the blood undergo any change while in the heart? Name four important changes that take place in the blood during its course through the body.

2. Describe the blood. What does the microscope reveal as to its composition? Contrast the two kinds of corpuscles. Give some account of coagulation. Of what substances is the blood made up?

3. Name the principal organs of the circulation. What is the heart's position in the body? Its size? What does *pericardium* mean? Describe the heart's cavities. Do the auricles open into each other? How many passage-ways lead into the heart? Out of the heart? Are there any other passages in this organ? What passages of the heart are always open?

4. How many valves are there in the right side of the heart? Describe the situation and action of the tricuspid valve. Of the semi-lunar valves. What valve between the chambers of the left side of the heart? How many passages connect with each auricle?

5. How does blood get into the lungs? How into the aorta? Describe the action of the heart, and the course of the blood in its chambers and passages. What is a heart-beat? The pulse? When does the heart rest?

6. Through what tubes does the blood pass out of the heart? What

artery opens out of the left side of the heart? Out of the right side? Which of these is the shorter? Why? How are most of the arteries placed in the body? Are there any valves in the arteries?

7. How does blood pass from the arteries into the veins? Describe the capillaries. Why are the capillaries of the lungs especially important? How does the blood in the capillaries nourish the various parts of the body?

8. Where do the veins begin? How does the work of the pulmonary vein differ from that of the pulmonary artery? Name the two largest veins in the body. Describe the venous valves. Are there valves in all of the veins?

9. Briefly trace the complete circulation of the blood. Where is the portal vein? The hepatic vein? The hepatic artery? What does *pulmonary* mean? Describe the pulmonary circulation. The systemic circulation. The portal circulation. What, strictly speaking, is the circulation of the blood?

10. Which side of the heart propels arterial blood? Venous blood? Are there any veins leading out of the heart? Does any artery carry venous blood? Out of what chambers of the heart do the arteries lead? What and where are the arterial valves?

11. What is assimilation? Give the literal meaning of the word. Are the lacteals helpful in this process? What is the function of the other lymphatics? Where is lymph taken up? In what direction is it carried? Why can not this process be reversed? Where and what are the principal losses of the blood in making its round in the body? The principal gains?

12. How and why does muscular exercise affect the circulation? How else may the circulation be invigorated, and the blood enriched? By what simple means may the circulation be impeded? What should be done in cases of arterial hemorrhage? What is fainting?

13. What is the effect of alcohol on the temperature of the body? Of reduced bodily temperature upon the circulation? What are the inhibitory nerves? How may their influence be impaired? How does alcohol injure the blood itself? To what organ of the circulation is the use of tobacco especially injurious?

CHAPTER IX.

RESPIRATION.

Etymology of Terms.

brŏn̲′chī (Gr. *brongchia,* the windpipe).

çĭl′ĭ ȧ (from Lat. *cilium,* eyelid; from the resemblance of the cilia to eyelashes).

lăr′yn̲x (Gr. *larungx,* a whistle; hence the whistle-like voice-box).

phthī′sis (Gr. *phthiein,* to waste away).

pleū′rȧ (Gr. the side; hence the lining membrane of the sides of the chest).

trā′che ȧ (Gr. *trachus,* rough, rugged).

1. The air surrounds the body, at all times, in the form of an invisible, odorless, tasteless gas. It forms a vast ocean of fluid, enveloping the earth to the depth of many miles. It is most perceptible to the senses when it moves in a strong wind. The air is a mixture of several gases. The two principal parts of the air are oxygen and nitrogen.

Oxygen forms about one fifth of pure air. It is by the combination of oxygen with other substances that combustion, or burning, takes place. It is this union of oxygen with other elements that causes the warmth of the body. Oxygen is exhaled by all plants.

Nitrogen forms about four fifths of the air. It does not unite with other substances to burn them, nor does the nitrogen of the air enter into the structure of the animal bodies which breathe it. Its great service to man is that it dilutes the oxygen of the air, for the air would be too stimulating, and combustion too rapid, if it were composed of oxygen alone.

Carbonic acid gas forms an insignificant element in the air we breathe. It is produced by all kinds of combustion, by the decay of organic matter, and by the breathing of animals. It aids in supporting the growth of plants. Carbonic acid gas is not poisonous, but its presence in the air we breathe means the exclusion of oxygen, which is a necessity of animal life. Suffocation is simply oxygen starvation. Carbonic acid gas is thrown off by all living animal bodies, just as oxygen is thrown off by all plants. Animals and plants exchange these gases with each other, animals needing what plants reject, and *vice versâ*.

The amount of carbonic acid in the atmosphere of different regions has been estimated about as follows:

Open air of country	.4	in	1000	parts	of	air.
Open air of city	.5	"	"	"	"	"
In school-room, ventilated	2.0	"	"	"	"	"
In school-room, not ventilated	30.0	"	"	"	"	"
In bed-room, before airing	5.0	"	"	"	"	"
In bed-room, after airing	1.0	"	"	"	"	"
In exhaled air	40.0	"	"	"	"	"

Watery vapor, which is water in gaseous form, is a very small part of air. It is constantly evaporating from bodies of water, and from the moist earth. It is also exhaled from the lungs of animals.

We have seen that the body constantly requires to be nourished by food, and that this food must be circulated to all of the parts by the blood. But the body can not live by these processes alone, however nutritious the food, or however perfect its digestion and circulation. All living things *demand the presence of air*, and require that some portion of it shall constantly enter their blood, as the nourishing elements of food do, and be circulated to their parts. No other want is so urgent. Men may live for weeks without solid food, and may live for days without water, but the absence of air, for even a few minutes, causes death.

Plants spread their leaves in the air and sunlight, and take what they need from the atmosphere through the great surfaces thus exposed. Fishes obtain air by means of their gills, from the water in which they swim. The higher animals that live in the air, take it into their blood through very thin membranes, arranged in the chest, called lungs. The process by which portions of the air pass into and out of the blood is called **respiration.** Respiration consists of two processes: (1) *inspiration*, or in-breathing, and (2) *expiration*, or out-breathing.

2. Outline of the Breathing Process.—The chest, in which the lungs are placed, is open to the external air by a set of passages connecting with the nose and mouth. By the action of certain muscles, the chest is enlarged, so that the air rushes in, and, after a short interval, is made smaller again, so that the air is forced out. By repeating these changes in the size of the chest, the air alternately passes into and out of the lungs.

The air is separated from the blood that is contained in the capillaries of the lungs by a very thin, moist membrane. The oxygen of the air readily passes through this thin membrane into the corpuscles of the blood, and is then whirled away by the blood to every portion of the body.

3. The organs of respiration are the air-passages, the lungs, and certain muscles that cause the breathing.

The air-passages are: (1) The *nasal openings*, which lead back to the pharynx; (2) the *larynx*, a short, cartilaginous box, in which the voice is produced; (3) the *trachea*, or windpipe, leading from the larynx to the central part of the chest; (4) the branches formed from the trachea, called *bronchi*, and their subdivisions, called *bronchial tubes*. Fig. 62 is a diagram of the lungs and air-passages, with the larynx at the top of the figure, and the trachea leading downward from it. The dark portion of the figure, to the right, represents the left lung entire. On the opposite side, the substance of the right lung is represented as removed to show the bronchial tubes.

4. The trachea is a membranous tube, four or five inches long, and about an inch in diameter. It is formed mainly of C-shaped cartilages, from sixteen to twenty in number, placed one above another. These cartilages, give the trachea a rough and ribbed appearance, and serve to keep it open for the passage of air which could not, like denser substances, make its way along a soft tube. The open sides of the cartilages are arranged in a line at the back of the trachea. This makes easy the passage of food through the esophagus, which lies behind and alongside of the windpipe. When we use the voice, however, the C-shaped cartilages contract to an O-shape, giving firmness to the air-tube at a time when it needs special strength because of the restrained volume of air within it.

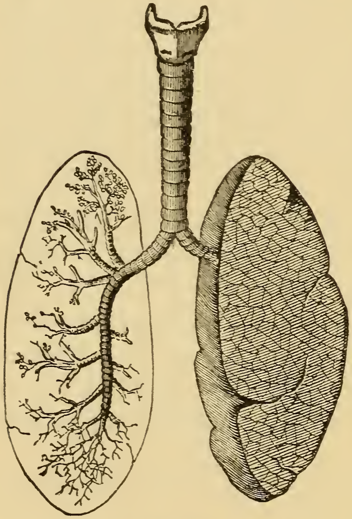


Fig. 62.

Ideal Diagram of Lungs and Air-passages.

The trachea has two great branches, called the **bronchi** (see Fig. 62), each an inch or two in length, and very much like the trachea in structure. On entering the lungs, the bronchi divide and subdivide into what are known as **bronchial tubes.** These send out smaller and smaller branches, somewhat as a tree sends out limbs, shoots, and twigs, till at last the many hollow channels in the tissue of the lungs terminate in microscopic air-cells.

The *air-cells* have extremely thin membranous walls, which separate the air within them from the blood in the capillaries of the lungs. There are many millions of air-cells, covered by a network of these capillaries, so that the combined surface for gaseous diffusion and interchange is very great. Fig. 63 shows how the bronchial tubes end in clusters of air-cells.

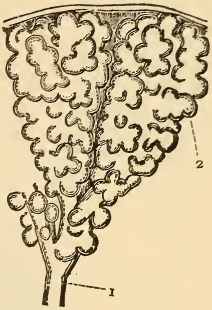


Fig. 63.

CLUSTER OF AIR-CELLS.

1, end of bronchial tube; 2, air-cell.

The lining of the air-passages is very sensitive, especially in the larynx and trachea, so that any foreign body that may be drawn into them causes pain and violent coughing until it is expelled. The lining of the bronchial tubes is covered with peculiar hair-like processes, called *cilia*, which aid in removing dust from the lungs and air-passages.

5. The lungs are two large, soft, pinkish lobes that, together with the heart and the great blood-vessels, fill the chest. Heart and lungs are close together because they are intimately related, and are dependent upon each other for their action. (See Fig. 64.) The lungs are sponge-like in their elasticity, and so light is their substance that it will float in water. These two large lobes, which surround the heart, when divested of all substances but their own tissues, weigh only about two pounds. The lungs are formed of the bronchial tubes and air-cells, and of the blood-vessels of the pulmonary circulation. Elastic, fibrous tissue fills the spaces between these various tubes, to support and bind the whole together. These two great sets of passages, the one for the air, the other for the blood, are arranged so as thoroughly to expose the blood to the action of the air. Though compacted in small space, they present an extensive blood surface to an equally extensive surface of air. The outside of the lungs is covered with a delicate, closely adhering membrane, called the *pleura*. This membrane also lines the inner walls of the chest. In all movements of the lungs these two smooth surfaces glide upon each other, so that the friction is very slight.

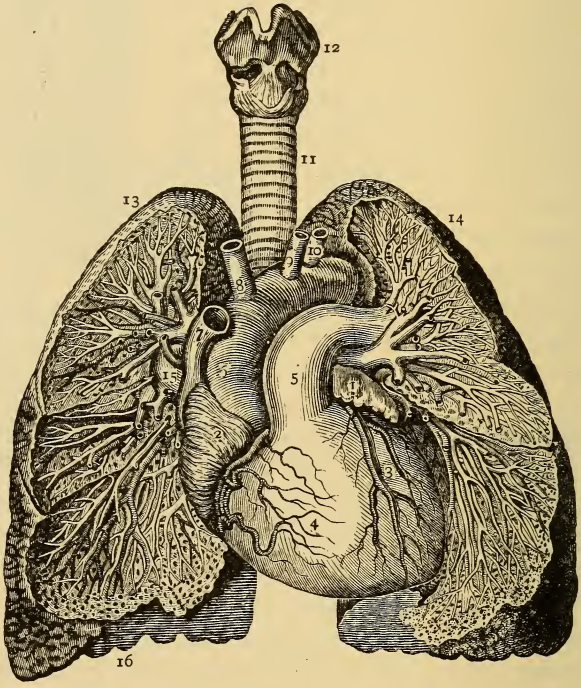


Fig. 64.

ORGANS OF THE CHEST, THE LUNGS PARTIALLY LAID OPEN.

1, 2, 3, 4, the heart; 5, pulmonary artery; 6, aorta; 7, upper vena cava; 8, 9, 10, branches of aorta; 11, trachea; 12, larynx; 13, 14, 16, lobes of the lungs; 15, right branch of pulmonary artery.

6. The movements of the chest, that cause the air to flow into and out of the lungs, are produced by the action of the *diaphragm* and *intercostal muscles*.

The diaphragm is a thin, broad, circular partition across the body, separating the abdomen from the chest. (See

Fig. 66.) It forms the floor of the chest, and is arched upward, like an inverted saucer, fitting closely under the lungs. Its outer edge is fastened to the walls of the body, with the muscular fibers extending inward toward the center. When these fibers are contracted, the diaphragm is pulled down and made more nearly level. This elongates the cavity of the chest.

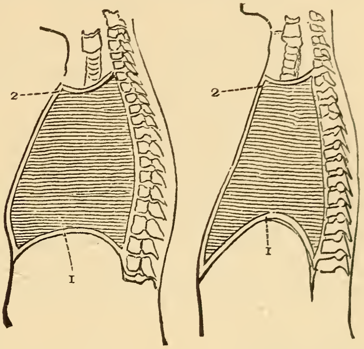


Fig. 65.

Inspiration and Expiration.

1, diaphragm ; 2, sternum.

At the same time, the **intercostal muscles** (see Fig. 66), whose fibers fill the spaces between the ribs, contract and lift the ribs upward and outward, broadening the cavity of the chest. By these two actions, the chest is expanded in all directions, and this enlargement causes the air to flow into the lungs. The fully expanded chest is represented in the first ideal section, Fig. 65.

When the intercostal muscles relax, the elastic parts that have been pulled out of shape return to their original form and position, so that the chest becomes smaller, and forces a part of the air out again. In the second section of Fig. 65, we see the chest represented at the close of an expiration.

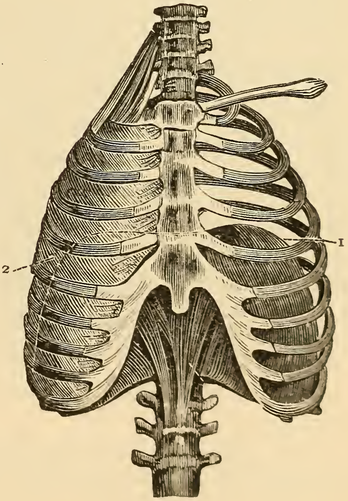


Fig. 66.

Chest Bones and Muscles.

1. arch of diaphragm ; 2. intercostal muscles.

7. The organs of the chest, unlike those of the abdomen, are protected at the sides and top by a bony framework. The floor of the chest is a muscular partition, through openings in which blood-vessels and the alimentary canal penetrate, but by way of tubes that are tightly closed around these openings. Accordingly the *trachea* is the only passage-way by which air can pass into the cavity of the chest. At the top of this passage-way is the *larynx*, which opens into the throat, and which is protected against the admission of everything but air by the *epiglottis* (see p. 198), a lid that is shaped somewhat like the inverted bowl of a spoon.

Respiration as performed by the chest walls and muscles through the windpipe has been well likened to the action of a bellows having but one opening—that at the nozzle. If the leather of the bellows were imagined to be living muscle, and the wooden parts to be bone, and if the bellows were only about half closed at each expulsion of air, the likeness to the movements of respiration would be still closer.

The lungs at all times contain air. Their *capacity* at time of full inspiration is about one gallon, and at time of expiration twenty to thirty cubic inches less. In each inspiration about a pint of new air enters the lungs, to mix with what is already there, so that in exhaling, some of the old air passes out. The air in the lungs is constantly mixing and changing places with that which is breathed in, so as to be entirely renewed in a short time. By this means the air that is next to the blood is not suddenly changed, and cold air does not come in contact with the delicate surfaces of the air-cells.

The frequency of respiration depends upon the rapidity of the circulation of the blood. Usually, there are from seventeen to twenty inspirations and expirations to the minute. If the circulation is increased, the breathing is usually more rapid.

The following estimates have been made of the capacity of the lungs of the male adult:

Residual air that can not be exhaled . . .	100	cubic inches.
Reserve air that is not ordinarily exhaled .	100	" "
Volume of ordinary respiration.	30	" "
Ordinary capacity, about	230	" "

The left lobe of the lungs is somewhat smaller than the right lobe, because the heart, though situated nearly midway of the chest, lies slantwise from upper right to lower left, so that the large and muscular ventricles are mainly to the left of the central line.

8. The lungs are sometimes classed as organs of excretion. Their function, however, is really double. Both absorption and excretion take place through their means. The *changes in the air* we breathe are first to be noted. While air is in the lungs it undergoes two changes: (1) a large part of its oxygen, the element of the air which warms and strengthens our bodies, is taken into the blood; (2) carbonic acid gas, which is waste matter from the blood, is taken up by the air to be thrown off in expiration. Small quantities of watery vapor and of

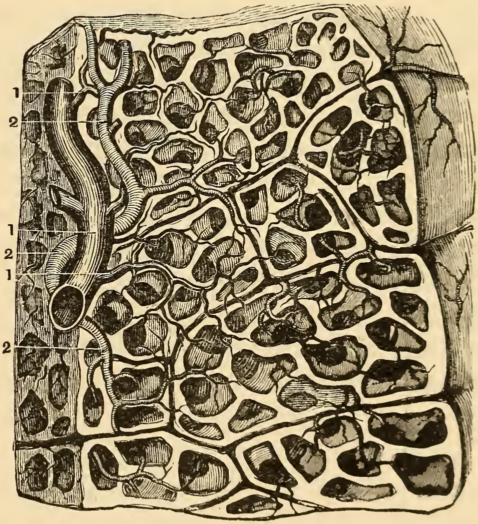


Fig. 67.

Magnified Section of Lung.

1, branches of pulmonary veins; 2, branches of pulmonary artery.

organic matter are also breathed out with the carbonic acid gas. The presence of these substances in the exhaled breath may be shown as follows: By breathing into a glass containing some lime-water, a chalky sediment will be formed in the water by the carbonic acid contained in the breath; by breathing on a cold pane of glass the watery vapor of the breath will be condensed into a film of water on the glass; by breathing into a bottle, and keeping such breath confined for a short time, a bad odor is developed in the vessel by the organic matter of the breath.

These changes that occur in the air while it is in contact with the blood in the lungs show plainly what must be the *changes in the blood* that take place at the same time. The blood that passes to the lungs through the pulmonary artery is, as we have seen, the dark, impure venous blood that has just returned to the heart from the system. In passing near the air-cells in the lungs, the blood receives the oxygen of the air, and gives off some of its carbonic acid, water, and organic impurities. (See Fig. 67.) The color of the blood is changed from a dark, bluish hue to a bright scarlet color, and it returns to the heart greatly purified.

The following table shows the principal changes produced in the blood by its passage through the lungs.

	VENOUS.	ARTERIAL.
Oxygen	8 per cent.	18 per cent.
Carbonic Acid	15 to 20 per cent.	5 per cent.
Color	Dark blue	Scarlet.
Water	More	Less.

9. Uses of Oxygen in the Blood.—It is mainly the oxygen of the atmosphere that enters the blood corpuscles in their passage through the lungs. This oxygen is distributed throughout the system by arterial blood, and unites with the carbonaceous food, and other substances, in the capillaries and tissues. By this union, a slow change takes place called combustion, by which *heat is liberated* to the surrounding parts, much as heat is set free by an ordinary fire. The products of this combustion are carbonic acid gas, water, and various salts, all of which are contained in venous blood as impurities. Oxygen also *consumes the waste tissues* of the body, thereby producing more impurities in the blood, while still further increasing the bodily warmth.

Respiration not only produces animal heat by the union of oxygen with nutrition and with waste, but, in coöperation with the functions of the skin, maintains with wonderful exactness the *equable temperature* of the body.

In active exercise, when much heat is radiated from the system and used up in changes going on within it, the lungs expand more fully and more frequently, and thus receive more oxygen to generate new heat. In repose this process is reversed.

In cold weather, when the temperature of the air is far below that of the body, more oxygen is contained in the same volume of denser air breathed in than is the case in summer, and the changes that this oxygen brings about increase our warmth. In winter, moreover, perspiration is almost wholly insensible, and hence there is no such cooling of the surface by evaporation as takes place in hot weather. Contrariwise, the air of summer contributes less oxygen to each inspiration, and sensible perspiration by its evaporation lowers the bodily heat, which would else increase till it became fatal to us.

10. Hygiene of Respiration.—Since respiration immediately affects the purity of the blood, it is evident that the health of the body must be greatly influenced by the kind of air breathed. Outdoor air is pure. It contains the proper amount of oxygen, and the other components are so completely diffused that they are not injurious. The air of dwellings is generally deficient in the amount of oxygen, and contains various impurities. This difference exists, (1) because the air of houses is not sufficiently free to circulate with the outdoor atmosphere, and (2) because it receives emanations from the bodies of those who live within, together with impurities arising from heating, lighting, cooking, etc.

Especially does the air of sitting-rooms and sleeping apartments, of school-rooms and factories, of churches and public halls, contain an excess of carbonic acid gas and organic matter, while the oxygen is speedily reduced below the proper amount. The process by which the foul air of rooms is replaced by fresh air is called **ventilation.**

The organic impurities thrown off from the lungs and skin are of the most noxious character. Air containing such impurities is unfit to be breathed again. Especially is this true of the air breathed by persons afflicted with disease. For the sake of the individual who is sick, as well as for the safety of the attendants, sick-rooms should be carefully ventilated. Sleeping-rooms need sunlight and fresh air during the day, and at night they should have sufficient openings at windows and transoms to permit change of air. An open fire will ventilate a sitting-room, while if closed stoves and heaters are used, there must be other ventilating openings beside those of the cracks of doors and windows.

Ventilation depends on the movement of air in currents, caused by differences in temperature. Warm air, being light rises, while cold air, being heavier, descends. Special contrivances for ventilation must admit fresh air and conduct away foul air. The passages for the exit of foul air should lead into warm flues or chimneys, so that there may be a sufficient upward current. The fresh air that is admitted may be warmed before it enters by passing it over heating surfaces. The air arising from cellars should in no case be allowed to enter the rooms of dwellings. Cellars should have openings of their own for ventilation. The morbid effects of impure air are restlessness, irritability, dullness, headache, and loss of appetite. These effects are due, not so much to casual impurities that exist in the air itself, as to the reabsorption into the body of impurities already thrown off by the system. (See Chapter XIV.)

The most common and fatal disease of the lungs is *pulmonary consumption.* This disease consists in actual disorganization of the substance that composes the lungs. It occurs most frequently from heredity, in which children suffer weakness as a result of the diseased conditions of their parents. Consumption may have its origin in injuries resulting from frequent heavy colds ; or it may result from continued impurity of the blood. The most robust person, if exposed to foul air for a long time, may finally yield to a tendency to consumption. On the other hand, persons who have inherited the disease are comparatively safe from it if they live sufficiently in the free air and sunlight, in regions in which the air is dry, and the temperature equable.

11. Besides the precaution concerning the purity of air, much attention needs to be given to **fullness of breathing.** The amount of air taken is quite as important as its purity. The chest requires free movement, that sufficient air may enter the lungs. The lower portion of the chest is naturally the larger and the more yielding as a means of full and deep respiration. To lace this part of the chest deforms it, makes the lower portion more slender than the portion above, and robs the chest of freedom of motion. By this deformity, the liver and stomach are crowded downward, and the breathing capacity of the lungs is greatly diminished.

The lungs are often seriously injured by habitually sitting or standing in such **position** that the chest is cramped and the breathing is limited and feeble. By persistent attention, one may acquire the habit of holding shoulders back, and, by full breathing, may permanently increase the capacity of the lungs. The erect position and full chest are typical of health and strength. There are three features of correct breathing that no one can afford to neglect:

1. Breathe pure air.
2. Wear loose clothing.
3. Maintain an erect position and full inspiration.

In breathing, the proper opening for the passage of air is the nose. The passages to the lungs from the nasal openings are longer and narrower than is the passage from the mouth. Air breathed in through the nose is therefore better warmed before it reaches the delicate tissues of the lungs than if received through the mouth ; and dust and impurities of all kinds that may be in the air are more likely to be intercepted by the lining membrane of the nasal passages. The mouth is not primarily an air-passage, and it is injurious to the throat and lungs to breathe habitually through it. One should be careful to sleep with the mouth closed.

Muscular tissues are injured, as has been shown, by **alcohol.** Since respiration is so largely dependent on the action of the diaphragm and intercostal muscles, alcoholic liquors are injurious to this function as to all others of the healthy body.

The notion that some alcoholic liquors are a cure for consumption is a mere fallacy ; they are much more likely to be a cause than a cure. One form of consumption (alcoholic phthisis) is a direct result of liquor-drinking. Alcohol inflames the delicate tissues of the lungs, paralyzes the nerves of the blood-vessels, and thus reduces the general vitality.

Tobacco greatly injures the lungs, the smoke of cigarettes being especially irritating to their delicate cell-structure. Habitual smoking of tobacco tends to bring about catarrh of the nose and throat.

QUESTIONS.—1. What gas is thrown off from the body by the lungs? What becomes of this gas? What two gases form most of the air? Which one of these gases is common to air and water? How do carbon and nitrogen become parts of our bodies? What is combustion? Is respiration a single, or a double act?

2. Give an outline of the breathing process. With what department of the blood's circulation is respiration most intimately connected? How does air find its way into the lungs? By what kind of force is air breathed in?

3. Name the air-passages. Which of these are entirely outside of the lungs? Entirely inside of the lungs? What air-passages connect the trachea with the bronchial tubes? What does *bronchi* mean? Are the bronchi parts of the wind-pipe? Why is the larynx so named?

4. What is the origin of the word *trachea?* Why are its cartilages C-shaped? Are they elastic? What is the advantage of this? Describe the branching of the air-tubes. What are the air-cells of the lungs? Does the air they contain come into immediate contact with the blood? What artery has branches in the lungs? Describe the protective lining of the bronchial tubes.

5. What organs are shown in Fig. 64? What two great arteries? Which of them carries blood to the lungs? Give some account of the position, size, shape, and texture of the lungs. The heart and the lungs fill the chest; both are in continual motion—how is friction prevented in the case of the heart? Of the lungs?

6. What important muscles of the chest were named in Chapter III.? Describe the diaphragm. How is it made fast at the back (see Figs. 65 and 66)? As shown in Fig. 66, is the diaphragm contracted or relaxed? How does its contraction affect the capacity of the abdomen? Of the chest? Where are the intercostal muscles? What is the effect of their contraction? Is muscular force required to expel air from the lungs?

7. How do the walls of the chest differ from those of the abdomen? Illustrate by a mechanical figure the movements of respiration. What is the capacity of the lungs? Does expiration empty them of air? Why not? Why does bodily exercise increase the activity of the lungs? How rapid is normal respiration? What proportion of the air contained in expanded lungs is ordinarily respired?

8. What does the air lose in the lungs? What does the blood lose in the lungs? By what simple experiment may it be proven that expired air contains carbonic acid? What is it that makes arterial blood scarlet? What is the chief end to be attained in respiration? Might the lungs be regarded as organs of the circulation?

9. In what two ways does oxygen raise the bodily heat? Where does this union of oxygen with other elements take place? How does respiration help to maintain the evenness of bodily temperature? What other organ coöperates with the lungs in this, and how?

10. What is ventilation? When and why is it needful? Which needs the more ventilation—a school-room, or a kitchen, and why? Is pure air necessarily cold? Which is the heavier—hot air, or cold air? Whereabouts in a room should warm air be admitted? What is consumption?

11. Where are the floating ribs? How does their compression affect the lungs? When the lungs are contracted, what must be the effect on their air-passages and blood-vessels? How else than by pressure from the outside may the lungs be cramped? Give three simple rules of healthful respiration. Should we breathe through the mouth? How are the lungs injured by the use of alcohol? By the use of tobacco?

CHAPTER X.

THE NERVOUS SYSTEM.

Etymology of Terms.

çĕr′e brŭm (Lat., the greater brain).

çĕr e bĕl′lum (Lat. diminutive of *cerebrum*), the lesser brain.

cŏn vo lū′tion (Lat. *convolutus*, rolled up).

crā′ni al (Gr. *kranion*, the skull).

găn′glĭ on (Gr. *ganglion*, a swelling).

me dŭl′lȧ ŏb lŏn gä′tȧ (Lat., oblong narrow).

pneū mo găs′tric (Gr. *pneumōn*, lung, and *gaster*, stomach).

sçī ăt′ic (Gr. *ischion*, the hip-joint), the largest nerve in the body.

1. The organs of the body, such as the muscles, stomach, heart, and lungs, have no power of themselves to perform their important work. They are controlled and caused to work together by what is called the nervous system. It is by means of this nervous system that we feel and move and think. By its means, different organs, remote from one another, have unity and order in their activities.

The nervous system (see Fig. 69) has certain great central parts, from which large numbers of tiny lines are distributed to the various parts of the body. By these centers and lines, all parts of the body are controlled.

The Nature of Nervous Tissue.—The matter of which the nervous system is formed is unlike any other in the body. Nervous tissue is three fourths water. It is a soft, pulpy substance, of extremely delicate structure. This nervous substance is very sensitive to the touch. Close examination with the microscope shows that nervous matter is of two kinds: (1) white matter; (2) gray matter. The *white matter*, which forms much the greater part of all nervous substance, is in the form of long, tubular fibers, about $\frac{1}{6000}$ of an inch in diameter, called nerve-fibers. By means of connective tissue, numbers of these nerve-fibers are bound together side by side, into cords, each of which is called a nerve. The *gray matter* is in the form of tiny cells, called nerve-cells. The nerve-cells are collected into little knots or masses, called centers. No gray matter is ever found except in these centers. The gray cells send and receive impressions; the white fibers carry them to and fro. All nerve-fibers begin in nerve-centers; some go to the skin, some to the muscles, and some connect nerve-centers with one another. (See Fig. 77.) The centers receive the impressions by one set of fibers leading to them, and send out impulses by another set of fibers leading from them. Each nerve-fiber does its own work independently of every other. How impressions are conveyed from end to end of the fibers we do not know, any more than we know how impressions made at one end of a telegraph wire are transmitted to the office at the other end of the line.

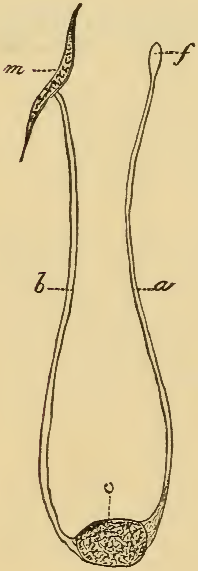


Fig. 68.

Element of Nervous System.

a, sensor fiber; *b*, motor fiber; *c*, center; *f*, end of sensor fiber; *m*, muscle.

2. Arrangement of Nervous Matter.—The simplest arrangement that can perform complete nervous action must consist of cells acting as a center, with one fiber leading to it, and another leading from it. In Fig. 68 *c* is the center; *a*, the fiber leading to it; *b*, the fiber leading from it. If the fiber *a* is irritated at the end *f*, the irritation is conducted to the center *c*. An impulse is then sent along the fiber *b* to produce motion in

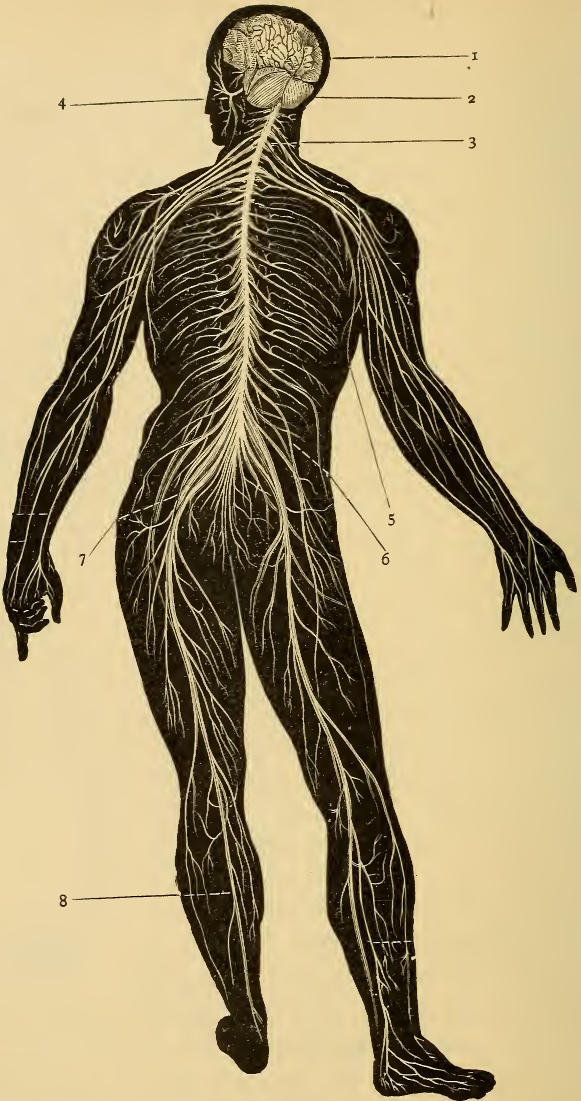


Fig. 69.

Diagram showing General Arrangement of Cerebro-spinal Nervous System.

1, cerebrum; 2, cerebellum; 3, spinal cord; 4, facial nerve; 5, intercostal nerves; 6, femoral nerves; 7, sciatic nerve; 8, branch of same.

the muscle *m*. You may illustrate nervous action by your own feelings and motions. If anything touches your finger the ends of the nerve-fibers in the finger are irritated. This irritation is conveyed to your brain and you feel the touch. You now send an impulse from the brain along the fibers leading to the muscles, and thereby move your arm. In this way you experience the complete action of nervous matter.

There are two principal **divisions of the nervous system:** (1) the part which aids in feeling, thinking, and moving; and (2) the part which controls the vital organs. The first division is called the *cerebro-spinal nervous system;* the second is called the *sympathetic nervous system.*

The cerebro-spinal nervous system consists, as its name denotes, of the *brain*, the *spinal cord*, and the various *nerves* that connect these two with the skin, muscles, and organs of special sense. Through this system, we know when anything touches us. Through this system, the mind learns the condition of the whole organism, and controls it. The nerves by which all parts of the body are put into close communication with the brain, may in fact be regarded as so many extensions of the brain substance.

3. The brain is the chief nervous center. It is contained in the skull, and is connected with all parts of the body by the spinal cord and the nerves that branch out from it. It is egg-shaped, with the smaller portion toward the front, and the larger portion fitting closely to the rear and lower parts of the skull. It weighs somewhat more than three pounds, or about one fortieth as much as the entire body. It is delicate and sensitive to pressure, blows, and jars; hence it is securely protected by the strong, bony case in which it is lodged. Besides its bony box, it is covered with membranes, and surrounded by fluids for still further protection. The membranes that cover the brain are three: (1) a tough, dense membrane, which lines the walls of the skull; (2) a soft, fine membrane, that lies next to the brain substance, and supplies the brain with blood; (3) a delicate, gauze-like membrane, lying between the other two, which is filled with watery fluid. The brain, although one fortieth the weight of the body, requires one fifth of the blood for its support.

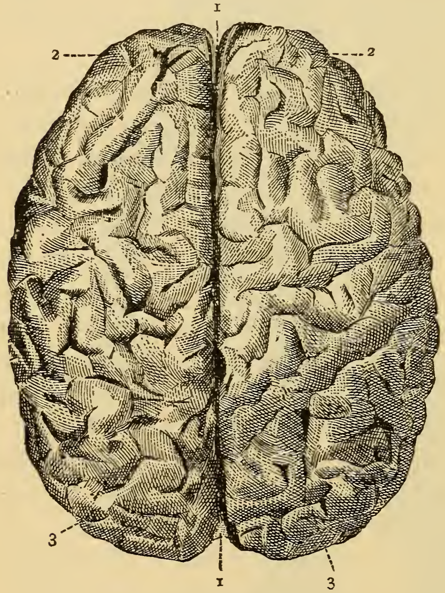


Fig. 70.

THE BRAIN SEEN FROM ABOVE.
1, great fissure; 2, frontal lobes; 3, rear lobes.

The brain ordinarily weighs about fifty ounces, and is generally large in proportion to the highness of intellectual power in the individual, though this is not a necessary relation, for many persons of recognized mental superiority have had quite small brains, while a few very large-brained persons have been indifferent in mental power. Evidently much depends upon the quantity of gray matter, quality of substance, and fineness of development. Among the results of examination of the brains of distinguished men, the following weights are given:

Cuvier	64.5 oz.	Abercrombie . . .	63 oz.
Napoleon	53 "	Schiller	63 "
Daniel Webster . .	53.5 "	Lord Campbell . .	53.5 "
Agassiz	53.4 "	De Morgan . .	52.7 "

4. The brain is separated, with the exception of a connecting bridge of white fibers at the base, into right and left hemispheres. This division is made by a deep fissure, extending through the middle, from front to rear. (See Fig. 70.) The halves thus divided are partially independent of each other. The brain is, therefore, a double organ, which corresponds with the halves of the body, and also with the double extremities. Either of the hemispheres of the brain may be seriously injured without necessarily fatal result. Some years ago, in Indianapolis, a man fell from the top of a load of hay and, striking upon a pitchfork, one of the prongs ran directly through the brain, from front to back. The prong broke off, and remained for several hours in the brain. It was then removed, and the man recovered, without serious injury to the nervous system or to the mind. During the war of secession there were many cases of recovery from gunshot wounds, in which the bullet passed completely through one hemisphere of the brain. A remarkable case of injury is upon record in which, in blasting with gun-

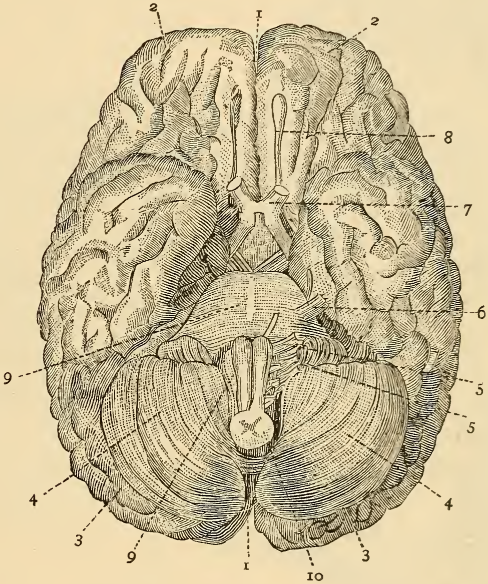


Fig. 71.

THE BRAIN SEEN FROM BELOW.

1, great fissure; 2, anterior lobes of cerebrum; 3, posterior lobes of cerebrum; 4, lobes of cerebellum; 5, 6, 7, 8, cranial nerves; 9, main body of medulla oblongata; 10, end of medulla oblongata.

powder, a pointed iron bar, three and a half feet long and one inch and a quarter in diameter, was driven completely through the side of a man's head. It entered the skull below the temple, and passed out at the top of the forehead. The man lay in a delirious, semi-stupefied state for about three weeks. At the end of sixteen months he was in perfect health, with the wounds healed and the mental and bodily functions unimpaired, except that sight was lost in the eye of the injured side.

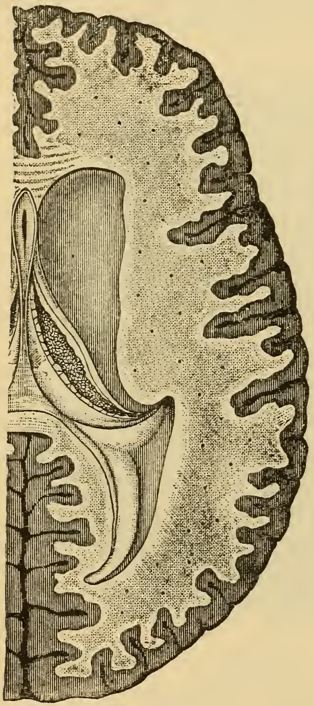


Fig. 72.

Horizontal Half-section of Brain, showing Gray and White Matter.

The brain is deeply folded and wrinkled. These folds are called *convolutions*. Its substance consists of both gray and white nerve matter, so arranged that the gray covers the entire surface to the depth of one fourth of an inch. This gray covering consists mainly of nerve-cells and blood-vessels. The white matter is within, and connects all parts of the brain with the spinal cord at the base. (See Fig. 72.) The brain has three distinct parts: (1) Cerebrum; (2) cerebellum; (3) medulla oblongata. (See Fig. 71.)

5. The cerebrum is the largest and most important part of the brain, forming about seven eighths of the whole mass within the skull. It occupies the upper portion of the cavity, projecting forward over the eyes, and backward over the cerebellum. Its surface is deeply and irregularly folded, and, if spread out, would cover about five square feet. (See Figs. 70 and

71.) The cerebrum appears to be the part of the brain that enables us to think. The gray matter arranged upon its surface is the true source of nervous force. The cerebrum presents many little bunches, or ganglia, of gray matter at its base, and contains a greater proportion of gray matter than any other part of the nervous system.

The cerebellum is situated under the rear portion of the cerebrum, lying just back of the ears. It is closely connected both with the cerebrum and with the medulla oblongata, presently to be described, which lies at the base of the brain. It is about one eighth the weight of the cerebrum, and is similarly composed of both gray and white matter. Its substance is not convoluted as is that of the cerebrum, but is arranged in parallel layers which present at the surface a series of ridges, and the whole is so arranged that when

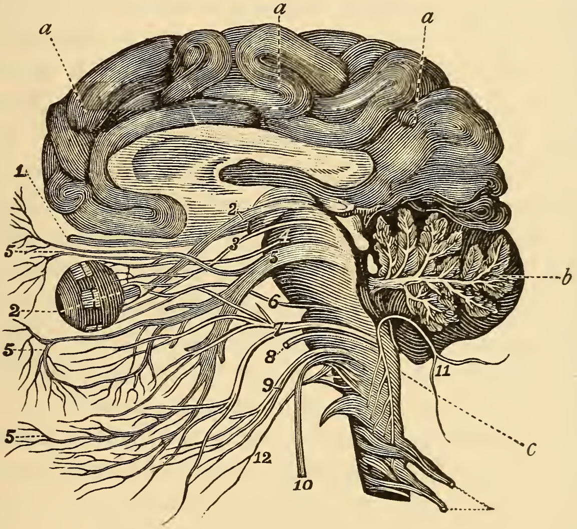


Fig. 73.

Right Hemisphere of the Brain, showing Cranial Nerves.

1, to nose; 2, 3, 4, 6, to eyes; 5, 7, to face; 8, to ear; 9, 11, to throat and larynx; 10, to organs of trunk; 12, to tongue; *a*, cerebrum; *b*, cerebellum; *c*, medulla oblongata.

the mass is cut the section shows a figure, called the *arbor vitæ*, because of its resemblance to the leaf of the tree of that name. (See Fig. 73.) The cerebellum appears to be the part of the brain which controls the muscular movements.

6. The medulla oblongata is that portion of the brain by which all the other portions are united into one mass, and the whole connected with the spinal cord. It is about an inch and a half in length, and forms the passage-way to and from the rest of the brain. It is the most exquisitely sensitive portion of the nervous system. From it arise nerves which connect the brain with organs of special sense, besides some other nerves of peculiar importance. (See Fig. 73.) These nerves are arranged in twelve pairs, and because they pass from the brain out through openings in the base of the skull, and not by way of the spinal cord, they are called *cranial nerves*. One of the nerves from the medulla oblongata, called the *pneumogastric nerve*, passes out to the stomach and lungs. This nerve controls the process of breathing. The least injury to the medulla oblongata at the origin of this nerve causes instant death.

If the *cerebrum* is removed, as has frequently been done with birds and other creatures, the animal may continue to live. It can stand or walk, it breathes, and digests its food, but loses all power of judgment—seemingly, it loses all mental activity. If the *cerebellum* is removed, and the remainder of the brain left uninjured, the animal appears to retain its mental faculties, continues its vital processes, but loses control over its voluntary muscles. The *medulla oblongata* is too sensitive, and too intimately connected with the processes of breathing and circulation to admit of mutilation without causing death. The spinal cord may be cut, by which injury all communication is destroyed with the part of the body below the point of division. From experiments, and from other data, it is thought that the cerebrum is the part chiefly engaged in mental activity;

the cerebellum, in controlling voluntary muscular motion; the medulla oblongata, in presiding over the vital processes; the spinal cord, in connecting the brain with the other parts of the body.

7. **The spinal cord** is a continuation of the medulla oblongata into the opening provided for it in the spinal column. It is protected by the vertebræ and by a continuation of the membranes that cover the brain, and since it does not quite fill the spinal canal, it is secure against pressure from the bony but flexible walls of this passage. The spinal cord is about fifteen inches long, and as large around at the upper end as the little finger. The substance of the cord is chiefly white matter, with some gray matter extending through the middle portion, thus reversing the arrangement of matter in the cerebrum, where the gray matter is exterior to the white.

Deep fissures, extending lengthwise of the cord, one in front and one at the back, almost meet each other in the middle of its substance. Fig. 74 presents a view of the right side of the spinal cord, showing the origin of the spinal nerves. The left side of the spinal cord is supposed to be cut away. 1 is a portion of the medulla oblongata, 2 is the frontal fissure, 3 is the root of the eighteenth spinal nerve of the right side.

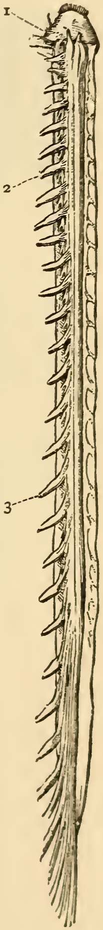


Fig. 74.

SPINAL CORD.

8. From the sides of the spinal cord, as a trunk, there originate thirty-one pairs of nerves called **spinal nerves.** (See Figs. 69 and 74.) These nerves branch out from opposite sides of the cord, at nearly regular intervals along its entire course, and pass out through openings between the vertebræ. Each nerve springs from the spinal cord by

two sets of fibers, called its roots, one set of which comes off from the front, and the other from the rear of the side of the cord. These two sets of fibers soon unite to form one nerve, which afterward subdivides and leads away to certain parts of the body.

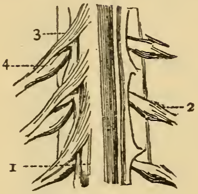


Fig. 75.

PORTION OF SPINAL CORD.

1, body of cord ; 2, a spinal nerve from left side of cord ; 3, frontal, or motor roots of a nerve ; 4, rear or sensor roots.

The fibers that come off from the rear of the cord are distributed to the skin, where they end in minute loops. These are the fibers by which we feel, hence they are called *sensor fibers.*

The fibers that arise from the front portion of the cord lead to the muscles, where they end in the delicate covers of the muscular cells. These are the fibers by which we move the muscles, hence they are known as *motor fibers.* By these two kinds of nerve-fibers, the various portions of the body are connected with the brain, and the whole organism is enabled to feel and to move.

The substance of the nerves is white matter. Each fiber of the nerve extends in an unbroken line from the center in the cord or brain, at which it originates, to the point at which it is to serve to give feeling or to produce motion. Thus every part of the surface of the body is put in separate communication with the seat of feeling, and the mind is enabled to tell just where the body is touched. In like manner, the mind can move any particular muscle.

The structure of the nervous system, and its manner of action, may be compared to the arrangement of battery and wires as used in telegraphy. The gray matter in the form of centers is like the battery cups in which, by chemical action, the electricity is generated, while the white fibers, that connect these centers and communicate with the skin and muscles, are like the telegraph wires, by which the messages are sent. The brain itself is like some central office, connected with a vast number of smaller offices and stations. At this center news is constantly received from all points, and from this center commands are sent out. The stimulus that is sent over the nerve-fibers is like electricity, in many respects, and by many students of physiology, it is thought to be electrical in its nature.

9. The sympathetic nervous system consists of a double chain of small, deep-set nerve-centers, one chain on each side of and near to the spinal column. This system extends the entire length of the neck and trunk, and has many other centers located elsewhere. (See Fig. 76.) From these centers arise numerous nerve-fibers, that connect the centers with one another, and with the various vital organs. These centers consist of the tiny rounded masses of nerve-cells, called ganglia. (See Fig. 77.) Some of the fibers of the sympathetic system connect with the spinal cord and brain. By this general union, sympathy between different organs is induced and regulated, and all the parts of the body are bound together as one organism. One of the members can not suffer injury or distress without causing all the others, even the brain itself, to suffer also. Thus the stomach can not be deranged without distress to the whole body. Pain can not exist in the heart without alarm to the whole body. One eye can not

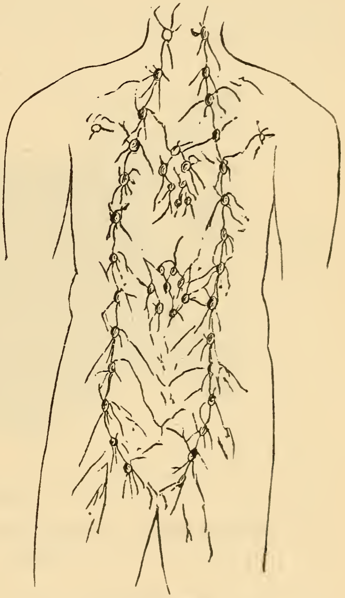


Fig. 76.

Diagram to indicate the Arrangement of the Sympathetic Nervous Centers and Fibers.

suffer without involving the other. It is because of this sympathetic union, established by this system, that it is called the sympathetic system. The numerous ganglia of this system act somewhat as so many little brains, which control the action of the vital organs independently of thinking in the cerebrum. We have no control over the nerves of the sympathetic system. They are concerned almost wholly in the movements of involuntary muscles. Accordingly the sympathetic nerves are not found in the extremities, whose voluntary movements are controlled by the nerves of the cerebro-spinal system.

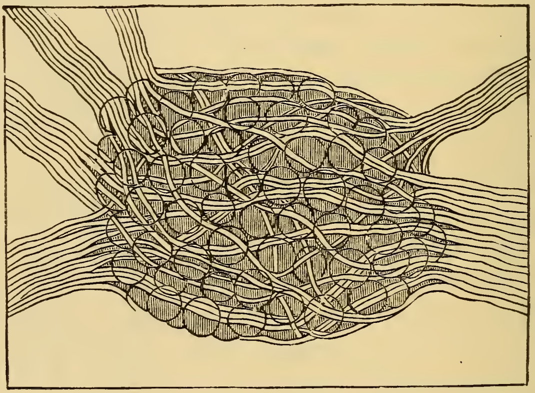


Fig. 77.

Nerve-center, showing Fibers, and Ganglion with Cells. Highly Magnified.

10. The fibers that have their outer ends in the skin are sensitive to touch and to changes in temperature. They convey the irritation they receive to the centers which are at their inner ends. The impression made on the brain causes the mind to feel. **Conscious action** of the nervous system results. The centers send out nervous impulses along the fibers that lead to the muscles. These impulses sent to the muscles cause motion. If your hand touches a rough object, the ends of the nerves are irritated, and this irritation is quickly conveyed to the brain. An impulse is sent to the muscles of your arm to move the hand away. The passage of irritation along the fibers is very rapid, so that the interval between the touching of the object and the taking away of the hand is very brief.

If the sensor fibers connecting any part with the brain are cut, or seriously injured, there is loss of feeling in the part. If the motor fibers connecting any muscle with the brain are cut or injured, all power of motion in the muscle is lost. If both kinds of fibers are destroyed, both feeling and motion are lost. These different conditions produce the various kinds of **paralysis.**

From various experiments, it appears that the fibers that connect the brain with the body cross over from the left side of the brain to be distributed to the right side of the body, and from the right hemisphere of the brain to the left side of the body. An injury to the left hemisphere of the brain, producing paralysis, affects the opposite side of the body. The fibers of the cranial nerves themselves do not cross from one half of the brain to the other. Accordingly, an injury to one hemisphere of the brain may paralyze the eye and muscles of the face upon the same side with the hemisphere, and the opposite side of the trunk and its extremities.

The brain itself is insensible to touch, for when the skull is broken or cut away the brain thus exposed may be cut or torn without producing pain. Protected as it is by the hard enclosing skull, it is unprovided with sensor fibers. The substance of the brain is readily paralyzed by pressure; if the skull is fractured, so that a portion of the bone presses upon the brain, the individual lies in an unconscious state until the pressure is removed, and unless relieved, he speedily dies.

11. The nerve-centers may send out motor impulses *without the conscious action of the mind.* If the irritation is extreme, the centers act before the mind has time to consider and direct the movement. In case your hand touches a hot object, you take the hand away instantly, before the mind has time to act. If you are scratched by a pin, you flinch instantly; if you are about to fall, you instantly catch your balance.

This action of the nervous system, in which the mind does not seem to act, but in which the impulse is intercepted and *reflected* off by some subordinate nerve-center, is called **reflex action.**

If the spinal cord is cut so as to destroy all connection with the brain, the nerves connected with the gray matter of the cord will still perform reflex action. If the part of the body supplied by these nerves is burned or pinched, the part thus injured will be thrown into violent motion. In this case, the mind can not receive any feeling from the injured portion, and is wholly unconscious that the motion is produced. This is positive proof that some of the centers may give impulses that cause motion without the action of the brain. Such action is purely reflex.

The uses of reflex action are of the most important character:

1. It relieves the mind.
2. During sleep it continues the vital processes.
3. It conducts the operations of the sympathetic system
4. It enables the mind to perform its usual acts with ease.

Reflex action not only directs the processes of the body, but largely invades the realm of intellectual and moral action. The whole matter of *habit*, whether of body or mind, is a manifestation of reflex action. As the nervous system acts once under certain conditions, so it is disposed to act again under similar conditions. By frequent repetition the action follows without thought.

Questions.—1. The lungs coöperate with the skin in excretion; with the heart in absorption and excretion—how is this harmonious action of different organs maintained? Where is the great center of the nervous system? Describe nervous tissue. What parts of the nerve tissues are fibrous? Cellular? White? Gray? What is the function of the gray cells? Of the white fibers?

2. Draw a diagram to illustrate the simplest kind of complete nervous action. Explain the diagram. What name is given to that division of the nervous system which controls the operations of the organs of the trunk? What is the meaning of *cerebrum?* Of *cerebro-spinal?* What are the functions of the cerebro-spinal nervous system?

3. Describe the brain—its situation; shape; size. In how many ways is it protected from injury? What proportion of the whole circulation passes through this organ? What is the average weight of the adult brain? The size of the brain, and mental power—is there any relation between the two?

4. What is the great fissure of the brain? How may we know that the hemispheres of the brain are partially independent of each other? Is the brain's surface smooth? What part of the brain is white matter? Name the three great divisions of the brain.

5. What division of the brain is the largest? What can you say of the convolutions of the cerebrum? What does *ganglion* mean? What are the chief functions of the cerebrum? Of the cerebellum? What are the situation, size, and structure of the "little brain"?

6. Describe the medulla oblongata. Why is this part of the brain so named? What are the cranial nerves? How are they arranged? Why are they so called? Which of them go to the organs of the trunk? What are the supposed functions of the cerebellum? Of the medulla? Give some reasons for these suppositions.

7. Describe the spinal cord—its origin; size; structure. How is it protected from injury? Where is its gray matter situated? Of which has the spinal column the more—gray matter, or white matter? What would be the appearance of a cross-section of the cord? In what does it terminate at its upper extremity?

8. How many pairs of cranial nerves are there? Of spinal nerves? Where do the cranial nerves pass out to their organs? The spinal nerves? Describe the roots of the spinal nerves. What fibers come off at the rear of the spinal cord? Where, and in what form, do the sensor fibers terminate? The motor fibers? Liken the structure and workings of the nervous system to those of the electric telegraph.

9. Where, and what, is the sympathetic nervous system? Why is it so

named? What kind of muscular movements does it control? Where are the centers of this system? Are its ganglia fibrous, or cellular? By which system of nerves are the movements of the extremities directed?

10. Which system of nerves communicates directly with the brain? What sort of action results from nerve impressions made directly upon the mind? Are sensations and acts of this kind simple or complex? What results from the cutting of a motor nerve? What is complete paralysis? Which half of the brain is affected in paralysis of the right eye? Of the right arm? Explain this.

11. Do all nervous impulses originate in the brain? What is reflex action? Give an instance of it. How may we prove the reality of it? Can you illustrate from telegraphy the interception of a nervous impression? What are the principal uses of reflex action? Thought has its seat in the brain; customary nervous impulses from any other center are not easily controlled by the will—what is *habit?*

CHAPTER XI.

HYGIENE OF THE NERVOUS SYSTEM.

Etymology of Terms.

ăn æs thĕt iȼ (Gr. *an*, without; *aisthesis*, sensation).

ȼhlō'ro fôrm (a word compounded from *chlorine* and *formyle*), a powerful anæsthetic.

ĕp'i lĕp sy (Gr. *epilepsia*, a seizure), hence, the falling-sickness.

he rĕd'i ty (Lat. *heres*, heir), the natural law of transmission by inheritance.

ĭn săn'ĭ ty̆ (Lat. *insanitas*, unsoundness).

mā'ni ȧ (Gr. *mainesthai*, to rage), madness, insanity.

môr'phĭne (Gr. *Morpheus*, the fancied god of sleep), a vegetable alkaloid of opium.

păr e gŏr'ic (Gr. *paregorein*, to soothe), an alcoholic tincture of opium.

1. Since all the other organs depend upon the nervous system for their control and energy, and since the mind has its seat at the center of this system, the health and vigor of the nervous system itself are of the greatest importance.

We can not afford to lose sight of the physical aspects of mental states if we would truly comprehend the nature of mental disease and learn to treat it with success. The physician who has to deal practically with the thoughts, feelings, and conduct of men, must recognize how entirely the integrity of the mental functions depends on the integrity of the bodily organization—must acknowledge the essential unity of body and mind.

Great waste of tissue and energy attends all nervous action. The nervous system, like all other parts, is dependent upon the blood for repair. Hence it follows that faulty nutrition and impurity of blood result in nervous weakness.

Impure air, by its effects on the blood, deadens the energies of the nervous system. Faulty excretion, by retaining impurities in the body, acts similarly. The nervous system suffers through imperfect respiration, insufficient diet, and imperfect digestion. Many substances, which are often taken as food, drink, or medicine, affect the nerves by paralyzing them.

Like all other organs, the nervous system needs **proper exercise** for its growth and continued vigor. The brain, as a bodily organ, requires for its best development that the individual shall have proper physical exercise. The brain, as the organ of the mind, requires proper mental exercise. The idle mind becomes weak, and unable to concentrate itself upon any subject continuously. By systematic exercise all the mental powers are invigorated—the memory being especially strengthened by use.

The nervous system and the mind are so closely related, that whatever affects one affects the other. When the system is healthful and vigorous, mental action is most forcible and reliable.

2. The nervous system needs periodic and complete **rest,** and this is to be found only in sleep. In our waking hours the activity of all parts of the body is accompanied by waste of tissue. As we have seen, the heart, the lungs, and the digestive organs secure rest in the brief intervals of their work; but the organs of special sense, and the brain and nerves are in constant activity so long as we are conscious. Only in sleep can the wear and waste of these be repaired.

The organic processes of circulation and respiration are also benefited by sleep, for although these processes are continued during unconsciousness, it is at a low rate of activity, and the waste is relatively slight. In perfect sleep all of the voluntary functions are suspended, and the organs of sense and the brain are in a state of absolute rest. The brain, especially, would otherwise break down. The efficiency of its action is in direct proportion to the frequent and regular renewal of its nerve-cells during the hours of rest and repair. Partial rest to the brain may be found in change from one kind of mental work to another. Recreation and amusement may relieve mental strain.

3. When taken into the stomach, **alcohol** is readily absorbed by the blood. The circulation quickly distributes the alcohol and brings it in contact with all the nerves and nerve-centers of the body, to which it is attracted because of the large amount of water contained in them. It hardens the extremities of the nerves, and makes them less sensitive. The power of acute feeling is lost, and epilepsy or paralysis follows. Moreover, it is the tendency of alcohol to prevent or hinder change in organic substances. This is its tendency in the case of nervous tissue, the vigor of which, as of all other tissues, depends upon nutrition. To hinder changes of the organic substances of the nervous system is, therefore, to impair its vigor. A large proportion of the brain is made up of albumen. Alcohol coagulates this, thus hardening and making rigid the delicate substance which lies at the center of the whole nervous system.

4. Alcohol inflames the nerve-centers. For a short time after taking alcohol, the drinker feels stronger, but in reality he is not so strong; he thinks that his mind is brighter, while in reality his judgment is impaired; the heart beats faster, the circulation is quickened, and the muscles are excited to action. This increase in the activity of the system is soon followed by a season of corresponding depression, in which there is dullness, weakness, stupidity, and lowness of temperature. If the quantity of alcohol taken is great enough, or if the dose is often repeated, nervous force becomes deadened, so that the patient is unable to walk or to think. It is because of these effects that medical writers call alcohol a narcotic poison.

Alcohol affects the whole mind. Whatever may be the relation of the nervous system and the mind, the effects of alcohol on the former cause the latter to be changed in all of its faculties. The effects of its action are seen in the following results :

1. Confused and faulty perception.
2. Impaired reason.
3. Loss of memory.
4. Erratic and excitable imagination.
5. Blunted sensibilities.
6. Loss of self-control.

It is the nature of alcohol ultimately to change the whole character. Under its influence, the kind and gentle become cruel and destructive ; the refined and delicate grow coarse and degraded.

The most characteristic and alarming effect of alcohol on body and mind is its tendency to **weaken the will,** and to fix upon the system a powerful appetite.

Because alcohol weakens the understanding and blunts the feelings, one under its influence loses the sense of right and duty. Moreover, the nervous system inclines to adapt itself to the treatment we give it. If we take alcohol, even in the lighter drinks, frequently and regularly, or any narcotic, the system soon becomes so accustomed to the effects that it will demand the substance by an appetite that is very difficult to control.

Both mind and body are disposed to form habits. The oftener we act in a certain way, the more powerful becomes the disposition to continue such action. The use of alcohol grows in this way to be a powerful habit, which often overcomes the strongest wills and most determined resolutions. The growth of this habit is rapid, and the appetite thus created is called the narcotic appetite. The same appetite is readily formed for tobacco, opium, chloral, or any other narcotic.

5. As the system becomes accustomed to the action of alcohol, it **requires a greater quantity** to produce the desired effect. Later, as the system grows less sensitive, it requires still greater quantities. It is usually true that those who become accustomed to the use of alcohol increase steadily in the habit; they drink more often, and they drink greater quantities.

It is true of all living things that the offspring resembles the parent. The conditions of the parent affect the constitution of the offspring in both physical and mental features Children born of parents who are profoundly diseased inherit deep-seated tendencies to similar diseases. So, too, children whose parents are addicted to the use of alcoholic drinks are apt to *inherit the appetite* for them.

Insanity is one of the most deplorable of human afflictions. It is now generally believed by physiologists that insanity is, in all cases, due to diseased conditions of the nervous system. These conditions may result from loss of sleep, lack of nourishment, exhaustion by disease, overwork, fright, grief, and any other great strains upon the nervous system. It occurs most often, however, as the result of heredity.

Because alcohol acts in all cases as a brain poison, its use tends to cause conditions favorable to insanity. Intoxication itself is temporary insanity. It is not surprising that frequently repeated intoxication tends to produce confirmed mania. Statistics derived from various asylums, both in England and the United States, show that the use of alcohol is one among the great *causes of insanity.*

In England, a committee whose observations extended through sixteen years, reached the conclusion that as many as sixty out of every hundred cases of insanity in that country, during the time of their investigation, were caused by the use of alcohol.

Dr. Yellowlees, Superintendent of the Glamorgan County

Asylum, says: "With the single exception of hereditary predisposition, intemperance is, by far, the most fruitful of all the causes of brain disease, and even hereditary predisposition is often but another name for parental intemperance."

Very many use alcohol in such quantities as not to cause intoxication. These persons drink wine and beer. They do so on account of the alcohol contained in them. They have used alcoholic beverages until they have formed an appetite for such drinks. It is this tendency to form a narcotic appetite that is one of the chief objections to the *moderate use of alcohol.* Alcohol is universally classed as a poison. Any use of it is dangerous, for the same reason that the use of arsenic, strychnine, or any other poisons is unsafe.

Dr. William Jay Youmans says: "It is to the nervous system, and especially to its great center, the brain, that alcohol is first attracted after it has entered the circulation. It is to all intents and purposes a cerebral poison."

Dr. James Edmunds says: "We have a great horror of arsenic and fifty other poisons; while the fact is, that all these things are a mere bagatelle in relation to the most direct, absolute, immediate, and certain poisonings which are caused by alcohol."

6. Tobacco is a poison. When chewed or smoked, some portions of it are absorbed by the blood and circulated through the system. Its effects are most fully shown in injury to the blood itself, and in paralysis of nervous force. The motor nerves, especially, are relaxed by the influence of nicotine, and the contractile power of the muscles is thus diminished. Its influence on the nervous and muscular systems is so powerful that its use in medicine is regarded as too dangerous for general practice.

The use of tobacco causes diseased conditions of the vital organs. The stomach, the liver, the heart, and the nervous centers suffer most from its use. By its narcotic effects, the use of tobacco fixes upon the system the most slavish conditions of the will. No intelligent man who uses it will advise another to do so. It is especially injurious to the young, because of its unquestionable tendency to stunt the growth of the body.

Opium is a gum made from the juice of the poppy. It may be smoked and chewed like tobacco. It is much used as a medicine, in the form of morphine, laudanum, and paregoric. Opium allays pain, and produces deep sleep. If a sufficient quantity of the drug is taken, the sleep which it produces ends in death. Like alcohol and tobacco, it is a narcotic poison. Its use, as stated on page 105, tends to produce an uncontrollable appetite for it. Its habitual use weakens the nervous system and impairs all the faculties of the mind.

Chloral hydrate, chloroform, and **ether** are drugs that are much used to relieve pain and to produce sleep. They should be employed only under the advice of a physician.

QUESTIONS.—1. What is meant by the physical aspects of mental states? Why should these receive careful consideration? How is waste of nervous tissue repaired? What hygienic inferences can you draw from this fact? The brain is not a muscle—how can we give it exercise? The mental faculties grow stronger by use—may we conclude from this that the brain also grows stronger in the same way? What is the effect of mental idleness upon the brain?

2. How does the nervous system get its rest? Are the heart and lungs rested during sleep? What other rest do they have? Are there any dreams in perfect sleep? With what class of organs are nearly all of the cranial nerves connected? Would sleep be possible unless sensation were cut off? Would sleep be possible if the movements of the vital organs depended on the will? State several methods of relieving mental strain.

3. How does alcohol pass from the stomach into the brain? Why is it used to preserve organic substances? What, then, must be its effect upon the activity of the nervous system? How does alcohol affect the albumen of the brain?

4. What is the primary influence of alcohol upon the nerve centers? What are its later effects? Does it injure all of the faculties of the mind? Enumerate six effects of the action of alcohol on the mind. What is the worst effect of the alcoholic habit? Of what kind of nervous action is the fixed appetite for alcoholic liquors a manifestation?

5. As the system becomes accustomed to the action of alcohol, what results? May the appetite be transmitted by inheritance? May tendencies to insanity be inherited? To what, then, may more than half of all insanity be attributed? Why is even the moderate use of alcohol unsafe?

6. What are the more obvious results of the use of tobacco? What is its influence upon the muscles? What muscular organ is especially injured by the use of this narcotic? Why is it particularly harmful to the young? What is opium? Name some of the familiar forms of this drug? What is an anæsthetic? Name some common anæsthetics.

CHAPTER XII.

THE SPECIAL SENSES.

Etymology of Terms.

ȼhō'roid (from Gr. *chorion*, skin; *eidos*, like).

ȼŏȼh'le ȧ (Lat., a snail-shell).

ȼon̲'ȼhȧ (Lat., a conch), the shell-like outer ear.

ȼôr'ne ȧ (from Lat. *cornu*, horn), from its transparent, horn-like appearance.

ī'ris (Lat., a rainbow), from its many colors.

laȼh'ry̆ mal (Lat. *lacrymosus*, a tear).

ŏs'si-ȼle (Lat. *ossiculum*, a little bone).

pē'troŭs (Lat. *petrosus*, stony), because this bone is of stony hardness.

rĕt' i nȧ (Lat. *rete*, a net), the branching network of the optic nerve.

sȼle rŏt'iȼ (Gr. *skleros*, hard).

ty̆m'pa nŭm (Lat., a kettle-drum).

vĭt're oŭs (Lat. *vitrum*, glass), glassy, transparent.

1. In cases of **common sensation** the mind is able to determine the exact part of the body at which the ends of the nerves are touched. The sensation is really produced in the brain, and the mind locates the feeling at the outer ends of the nerves. For instance, if the right hand is burned, the feeling is referred to the hand and to the exact portion that is injured. For this reason, we say that the hand feels. The acuteness of feeling in any part depends on several causes:

1. The highly sensitive parts have the greater number of nerves extending to them.

2. The ends of the nerves in these sensitive parts are so exposed as to receive more fully the effects of the irritation,

3. The continued use of certain parts in feeling develops their sensitiveness.

The relative number of nerves in the different parts of the body may be measured by using a pair of dividers as follows :

Place the two points of the dividers near together, and touch them to the tips of the fingers. We can discriminate the two points, even if they are brought almost together. Now place the points against the back, and we shall find that we feel but one point. The two points may be separated an inch or more, and yet we can feel but one point in touching them to some parts of the back. This is because there are relatively so few nerves on the back. Upon the cheeks, lips, fingers, or tongue, we can distinguish the two points, even if they are brought within the twentieth of an inch of each other. This is because the nerves are so much more numerous in these more sensitive portions.

When, from any cause, the nerves are very greatly excited, or are injured in their structure, the result is **pain.** Pain results, too, from the excessive use of any organ, and limits us in the use of our powers. Pain usually attends disease, and indicates what parts are suffering. Hence, as an evil to be dreaded, pain protects us from danger, prevents over-exertion, and tells us of the presence of disease.

2. Some parts of the body receive and send to the mind sensations of one kind, and other parts, sensations of other kinds. The skin touches, the tongue tastes, the eye sees, and the ear hears. All of these results are different feelings, coming from certain parts of the body. The mind learns by experience what these different kinds of feeling are, and learns also something about the various causes that produce them. In this way the mind gains different kinds of knowledge.

These special adaptations of the nervous system to receive various kinds of feeling, are called the **special**

senses. The special senses give the mind its varied knowledge of the world. They are the windows of the mind, through which we look out, and gain knowledge of the things about us.

The special senses are those of *touch*, *taste*, *smell*, *sight*, and *hearing*. The **organs of special sense** are, respectively, *the skin*, *the mouth*, *the nose*, *the eyes*, and *the ears*. While each of these is very sensitive to the peculiar irritation which it receives, it is not at all sensitive to the causes that excite the others. For instance, the eye may perceive the most delicate shade of color, but can receive no impression from the loudest sound; and the tongue, though able to detect the most delicate flavor, can neither hear nor see.

Each special organ of sense is supplied with special nerves; *i. e.*, nerves that are not used for any other purpose than for the peculiar feeling of that organ. These nerves lead to special nervous centers.

Touch.

3. The special senses have by some been classified as different manifestations of one sense—that of *touch*, since it is only by coming into contact in one way or another with exterior nature that we can have any cognizance of what is outside ourselves. In this view, waves of light touch the eye, vibrations of air touch the ear, food touches the tongue, and emanations from exterior substances touch the organ of smell, in just the same way as contact with various objects gives rise to what is commonly called the sense of touch. It is worthy of note that four of the five special senses have their organs in the head.

The cutis, or true skin, covering the entire body, is the organ of *touch*. It gives the mind knowledge of the contact of things that touch it. The skin feels also the temperature of things. The *hands* are the most useful and delicate organs of touch. They are used to feel objects, and from the effects produced, the mind learns whether surfaces are smooth or rough, warm or cold, hard or soft, and the like. In the act of grasping, the hand fits about an object, and is thus able to convey to the mind a feeling of its size and shape. By reaching out the hands and arms, the distance of bodies that are within reach is learned. It is by practicing the eye, in association with the hands, that the mind learns to judge of size, form, and distance. If we had never touched a round body, we could not judge accurately of its form by the eye alone. A sphere has the same outline as a circle. Glass and water have a like appearance, and, to one who had never touched them, they would look equally hard. To a young child, the moon seems as near as the window. Fig. 78 represents the nerves of the finger.

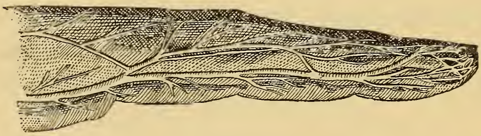


Fig. 78.

PRINCIPAL NERVES OF THE FINGER.

By its structure, the hand is adapted to be used as the organ of grasp and touch, and to serve the mind in many other ways, such as in writing, drawing, painting, sculpture, in performing on musical instruments, and in working at trades requiring great skill. The hand is very flexible, so as to adapt itself to almost any shape. Its many joints, muscles, and tendons give it the greatest variety of motions. Its movements are easy, light, and rapid. Its location at the end of the arm permits it to touch any other portion of the body. The two hands, acting together, perform thousands of intricate acts, and serve mind and body in numberless ways.

Any portion of *the skin* that possesses the sense of touch, consists of three parts:

1. A deep layer of fibrous tissue.
2. A delicate network of nerves (see Fig. 79) running through the deeper layer.
3. An outer, insensible layer, to shield the sensitive parts from injury.

Wherever the sense of touch is very delicate, as it is in the palms of the hands, and on the fingers, the deeper layer is raised into great numbers of closely set papillæ, about one one-hundredth of an inch in length. These project from the lower layer, and the insensible layer fills in between them, and covers their ends. The outer ends of the sensor nerves are in these papillæ. The papillæ are the most numerous in the more sensitive portions; it is estimated that there are twenty thousand of them to the square inch in the palms of the hands.

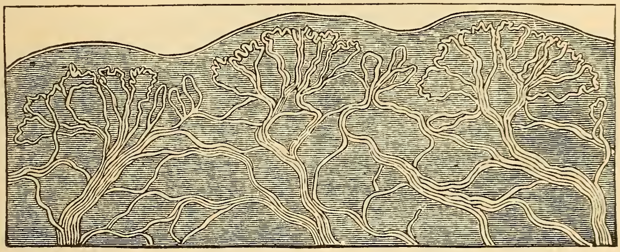


Fig. 79.

Fine Nerves of Touch at the End of the Thumb.

The acuteness of the sense of touch may be greatly increased by cultivation, and this is true of all the special senses. By fixing the attention upon the feelings produced, the mind learns to understand more readily the sensations made on the brain, and to perceive differences that would not otherwise be noticed.

The wonderful degree to which *education of the touch* may be extended is shown in the powers which the blind gain in learning to read freely from raised letters. These blind readers pass the tips of the fingers over raised print. They recognize the words by touch as the ordinary reader does by sight. To master a new word, they feel the letters, and spell it in that way. The blind can learn to perform skillfully on musical instruments, to do fine sewing, and to make many articles requiring rare skill. They perform these difficult tasks by the education of their sense of touch.

When, from any cause, one or more of the senses are lacking, or their power impaired, the force thus lost seems to be concentrated upon the other senses, one or all of which will be found to be more acute and powerful. The best illustration of this fact is found in the case of Laura Bridgman. When she was two years old a severe illness resulted in her loss of sight, hearing, and speech. Her sense of smell was also destroyed, and that of taste was much impaired. She therefore had but one sense to rely on ; viz., that of touch. Through a careful training of this one sense, she acquired a knowledge of arithmetic and geography, she learned to sew by hand and on a machine, to do household work and many other useful things. In course of time she herself became a teacher of the blind and taught with much success.

Taste.

4. The various substances that are taken into the hand produce various impressions on the nerves of touch. If these substances are placed in the mouth, they will affect in the same ways the sensor nerves of the mucous membrane covering the lips, cheeks, and tongue. They *touch* the parts of the mouth as they do the hand, and produce feelings of smoothness, softness, warmth, and the like, as they do in the hand.

In addition to these feelings, some of the nerves supplied to the mouth receive peculiar feelings from the objects that touch them. By these peculiar feelings, the mind learns the *taste* of anything, whether it is sour or sweet, salty or bitter. In order that substances may be tasted, they must, as we have seen, be moistened and dissolved, so as to come in contact with the nerves of taste. All articles do not produce taste, nor are all portions of the mouth supplied with these peculiar nerves.

The tongue is the organ of taste. The parts that are most sensitive to taste are the outer end of the tongue, its border near the teeth, and the surface of the back portion. (See Fig. 80.) The nerves supplied to it for tasting come, as we learned in Chapter X., from particular points on the medulla oblongata, and have their ends exposed on the surface of the tongue in a peculiar manner. The tongue, like the cutis, is covered with great numbers of papillæ, which give to it a velvety appearance. The salivary glands with which the mouth is supplied pour out their juices to dissolve food substances, and thus aid the nerves in tasting. The nerves of taste end in the papillæ of the tongue and about these glands. The border of the tongue seems most

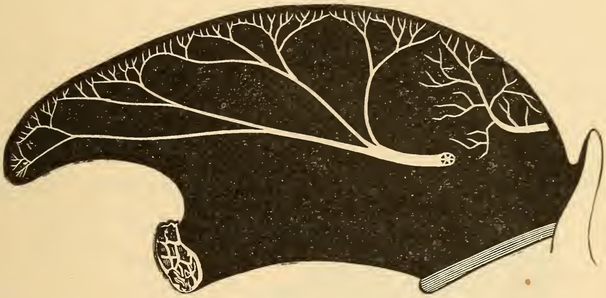


Fig. 80.

Diagram showing Distribution of Nerves of Taste.

easily affected by sweets and sours; the back portion is affected more by salts and bitters. The impression made on the nerves of taste remains for a short time, so that a strong taste can not immediately be removed from the mouth.

By the habitual use of substances that have strong or pungent tastes, we lose the ability to detect delicate flavors. The use of narcotics, such as **tobacco** and **alcohol**, deadens the sensitiveness of the nerves of taste. Very great delicacy of taste may be acquired by cultivation. This sense guides us in the choice of food, stimulates the salivary glands, and makes pleasurable the labor of mastication. The lower animals, whose tastes are natural, are seldom misled in selecting food.

Smell.

5. The nose is the special organ of smell. The gases and vapors that pass into the nose with the breath come in contact with extremely delicate nerves. These nerve fibers end in the moist, mucous membrane that lines the upper portion of the nose. The vapors or fine particles that strike against these nerves produce peculiar effects, which the mind knows as odor or smell. Every one is familiar with the fragrance of flowers, the savory odor

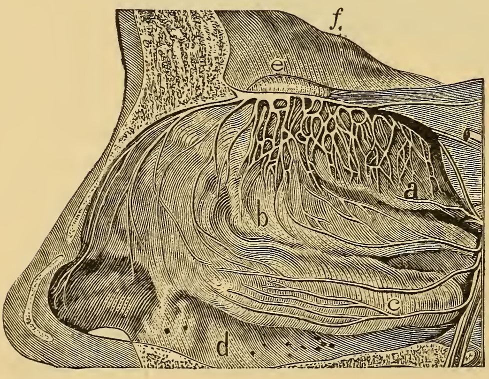


Fig. 81.

SECTION SHOWING RIGHT NASAL CAVITY.

a, *b*, *c*, *d*, nasal cavity; *e*, olfactory nerve; *f*, branches of same.

of cooking meats, and the offensive odor of decaying matter. These feelings, which we call smell, are produced by emanations that are floating in the air. These, upon being breathed into the nose, touch the nerves of smell, or olfactory nerves. The sense of smell is keenest in the upper part of the nasal cavities, where the many fine branches of the olfactory nerve are spread out. (See Figs. 73 and 81.)

Smell coöperates with taste in deciding our choice of food and drink. More particularly it is fitted to detect impurities in the air and thus to warn us against gases and vapors that are unfit to be breathed into the lungs. Smell is a more delicate sense than taste or touch, and in some of the lower animals is astonishingly acute. The deer can scent the hunter many rods away. The hound follows the trail of a hare by the smell arising from the pressure of the hare's feet on the ground and grass. He will follow his master's footsteps through the crowded street hours after he has passed along, by the odor arising from the pressure of the master's feet on the pavement.

Taste and smell are more special in their nature than is touch, although they all depend on the contact of objects or impressions with certain nerves.

Sight.

6. Light comes into our eyes from the things about us, and we see these objects. The light from a candle produces an effect on the nerves of the eyes, so that we see the candle. So by the light reflected from a book we see the book. This sense is called sight. By it we learn to judge of the form, size, color, and distance of objects.

The eyes are the special organs of sight. They usually act together, so that, in seeing anything, we use them both on the same object. We may see by using one eye alone. Those who lose the use of one eye learn to see with the remaining eye as others do with both.

The eyes are placed very near the brain, in the deep sockets, called orbits, just under the front part of the cerebrum. By this position, the eyes are high so that we may see far, and by the free movements of the head, the eyes may quickly be turned in any direction.

The bony orbits project around the eye, so that objects can not readily strike the ball. The brows, lashes, and lids prevent dust and sweat from entering the eyes. The lids close over the eyeballs like curtains, to shut out light while we are asleep, and while we are awake, they keep the eye clean and moist. To give the eyelids some firmness of texture, they are stiffened by minute plates of cartilage. The lining of the lids is a very sensitive membrane. If anything enters the eye, it gives pain to this membrane until it is removed.

The lachrymal glands are situated in the eye-sockets, just back of the outer end of the eyebrows. These glands secrete the tears from the blood and pour them upon the balls. Tears are constantly flowing into the eyes. They flow across from the outer upper corner to the lower inner corner, and pass into the nose through tiny tubes called lachrymal canals.

If anything gets into the eye to cause irritation, the tears flow in rapidly to aid in removing it. In weeping, the tears flow in so much faster than they can be carried off by the lachrymal canals, that they run over the edges of the lids. There are many sebaceous glands along the inner edges of the eyelids, whose secretion prevents the lids from sticking together, and the tears from flowing over.

The eyeballs do not fill the orbits, but are packed about by fatty matter, which forms a cushion on which the eyes may rest and move freely. The eyes are moved by muscles attached to the balls, and fastened to the back part of the orbits. There are three pairs of muscles to each ball. In the delicacy of its structure, and in the nicety of its adaptations, the eye is one of the most admirable of our bodily organs. By pressing the eyeballs between the thumb and fingers, we find that they are quite firm and hard. By taking the eyeball of an ox to pieces, we shall find that it is filled with jelly-like fluids, surrounded by an outer shell or wall.

7. The wall of the eye is formed of three layers or coats. (See Fig. 82.) The first or outer coat of the eyeball is thick and tough, and is called the **sclerotic coat.** It forms the white of the eye, and covers the front portion with a membrane called the *cornea*, which is transparent so as to admit the light. The cornea is kept clean and clear by the constant involuntary movements of the eyelids in winking. It bulges forward a little, as may be seen by looking at it from the side, for which reason it has been likened to the crystal set in the face of a watch. The sclerotic coat preserves the shape of the eye and gives it strength.

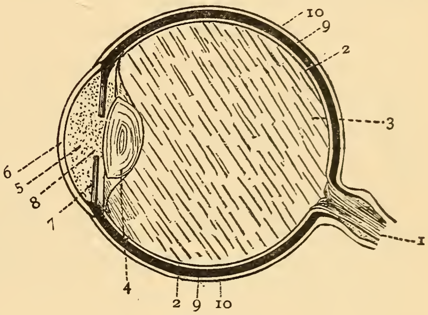


Fig. 82.

HORIZONTAL SECTION OF THE RIGHT EYE.

1, optic nerve; 2, retina; 3, vitreous humor; 4, crystalline lens; 5, aqueous humor; 6, cornea; 7, iris; 8, pupil; 9, sclerotic coat; 10, choroid coat.

The second or middle coat is the **choroid coat.** This coat is entirely made up of blood-vessels, and lines the interior of the eye with a dense black pigment which intercepts and absorbs surplus light. In front, this second coat forms the *iris*, which corresponds with, and has the same circumference as the cornea, and which gives color to the eye. Through the iris there is a round opening, called the *pupil*, through which light enters the eye. The pupil looks black, because through it we see the black walls of the choroid coat. The opening changes in size, growing smaller, so as to shut out some of the light when the light is too strong, and becoming larger as the light diminishes.

The third or inner coat is the **retina.** This is a very thin membrane, and has the nerves of sight spread out over its surface.

8. The transparent fluids that fill the eye are called **humors.** There are three humors:

1. The *aqueous*, or watery humor, which fills a small portion of the eye in front.
2. The *crystalline*, which is of the shape of a double convex lens, and which lies just back of the aqueous humor.
3. The jelly-like *vitreous* humor, which fills the main portion of the eyeball, and is surrounded by the retina. (See Fig. 82.)

The eyes are supplied with special cranial nerves, called **optic nerves,** which enter at the back and are attached to the eyeballs, somewhat as the stem of a cherry is attached to the fruit. They spread out on the inner surface of the rear portion only, where the light that enters the pupil falls.

9. We do not touch the things we see, as we do the objects we taste. The nerves of the eye are so delicate that they are affected merely by the light that is reflected from an object into the eye through the pupil.

Light is thought by scientific men to consist of wave-like vibrations of a subtle medium which pervades all space. These vibrations coming against the delicate nerves, irritate them.

The light passes off in all directions from objects in diverging straight lines. Some of these lines of light pass in through the pupil. In passing through the cornea and the crystalline lens, they are so turned from their course that all the rays or lines that come into the eye from any point on an object are brought together at one point on the retina, and all the lines from any other point of the object we see, are brought together at another point on the retina. In this way a complete image of the object that we see is made upon the retina. (See Fig. 83.) This image is very small, but is bright, and has the shape and color of the object seen. From this image on the nervous membrane of the eye, the mind learns to judge of the shape, color, direction, and distance of an object, just as it judges of other qualities of an object by taste or smell.

The image is so small that it seems wonderful that the mind can use it so perfectly. It may be that the whole landscape, which covers many miles in extent, is pictured on the back of the eye in an image so small that it would not cover more than the surface of the little finger-nail. The mind, however, can fix its attention on any point in this image, and see the same point in the landscape. The image in the eye is wrong side up, but the mind has learned by experience to reverse this impression.

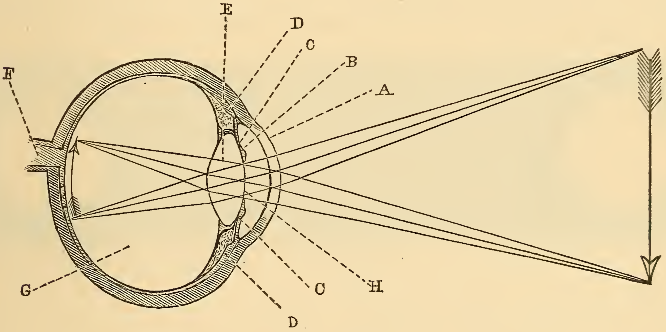


Fig. 83.

DIAGRAM SHOWING FORMATION OF IMAGES IN THE EYE.

a, cornea; *b*, aqueous humor; *c*, iris; *d*, sclerotic coat; *e*, crystalline lens; *f*, optic nerve; *g*, vitreous humor; *h*, pupil.

It is an interesting fact that the optic nerve itself receives no direct visual images. The point in the wall of the dark chamber where the optic nerve enters, and where we should expect the greatest sensibility to be, is known as **the blind-spot** of the eye. You may easily prove the existence of this blind-spot. Close your left eye, and look fixedly with your right eye at the white circle at the left of the diagram. (Fig. 84.) Though your attention is directed to but one of the circles, the other is visible also. Now move the book slowly toward the face, and you will find that, at a certain distance from the eyes, the circle at the right will disappear from view. This is because the rays of light from the circle at the right are brought together, or focused, upon the optic nerve of the right eye. If you will consider the position of the circle at the instant when it disappears, and the position at the same moment of the pupil of the eye that is open, it will be plain to you that the opening of the optic nerve into the eye—the blind-spot—is not at a point directly opposite to the pupil, but somewhat nearer to the center of the head. (See Fig. 82.) If the optic nerve entered the eye exactly opposite the pupil our direct vision would frequently be obscured.

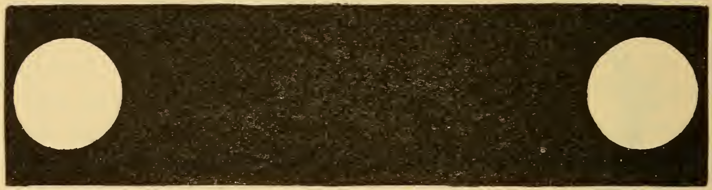


Fig. 84.

The image of any object upon the retina of one eye differs slightly from the image of the same object upon the retina of the other eye. This you can readily prove to yourself. Close one eye, and then bring any two objects that are some distance apart into line with each other as seen by the eye that is open. Then, without moving the head, close the open eye, and look with the other at the same objects. You will find that they are no longer in line with each other—they appear to have slightly changed their relative positions.

The two branches of the optic nerve, one to each eye, converge and unite, somewhat as do the arms of the capital letter Y, before passing into the brain. In some way that we do not understand, the images upon the two retinas, though unlike each other, are combined into **one impression,** made upon the mind by means of the optic nerve and the brain.

10. The crystalline lens brings the rays of light together on the retina to form the image. If the lens is too nearly round, it brings the rays together before they reach the retina, so that no image is formed. (See Fig. 85.) Those who have such eyes are said to be **near-sighted,** because they can see only objects that are very near the eyes. This defect of the eyes may be remedied by wearing concave glasses to counteract the convexity of the crystalline lenses.

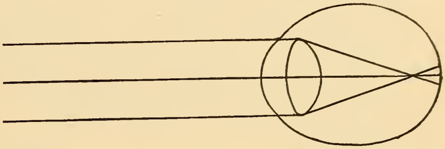


Fig. 85.

NEAR-SIGHTED EYE.

If the crystalline lenses are too nearly flat, the rays of light are not brought together upon the retina, and again no image is formed. (See Fig. 85.) Those who have such eyes can see only distant objects, and are said to be **far-sighted.** Many old people are far-sighted. This defect of the eyes is relieved by wearing eye-glasses that are convex, so as to counteract the concavity of the crystalline lenses.

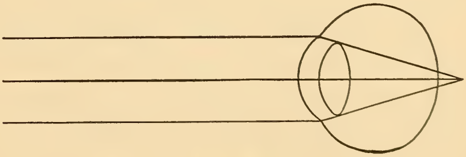


Fig. 86.

FAR-SIGHTED EYE.

Hygiene of the Eyes.—The eyes may be seriously injured by looking at objects that are very brilliant. To look directly at the sun is painful and injurious. By straining the eyes in trying to see in light that is too feeble, the eyes are injured. To read or sew by faint or unsteady light injures the eyes. The light, in reading, or in other cases in which the eyes are used continuously on the same object, should come from the back or the side, so that it will not enter the eyes directly, but will be reflected from the object.

The eyes may be injured by using them too intently, or too continuously on very fine work of any kind. To prevent injury in this way, the eyes should be rested and relieved by being used in other ways. Impaired vision is a frequent result of the use of alcoholic drinks and tobacco.

If, from any kind of use, the eyes become inflamed, the best relief is to give them perfect rest. Keep them closed, wear colored glasses for a time, or remain in darkened rooms, if necessary. If an object gets into the eye and causes pain, remove it promptly, by lifting or turning the lid, and taking the folded corner of a soft handkerchief, or the rounded end of some smooth object. Do not rub the eye, nor wipe it excessively, for such practices will increase irritation. (See p. 226.)

Hearing.

11. The ear is the special organ of hearing. The ears are less closely related than are the eyes. For protection, the ears are located at the base of the skull. The internal portion of the ear, which is the most important part of it, is inclosed in a very hard part of the skull, called the *petrous bone*.

The ear has three parts: (1) the outer, (2) the middle, (3) the inner. (See Fig. 87.)

The outer ear includes: (1) the visible shell-like part that projects from the side of the head; and (2) the canal, or air tube, leading into the middle ear. The shell-like part is called the *concha*, and is formed of thin cartilage, covered with skin. It catches the sound, and directs it toward the inner parts of the ear.

The canal leading from the concha is an opening through

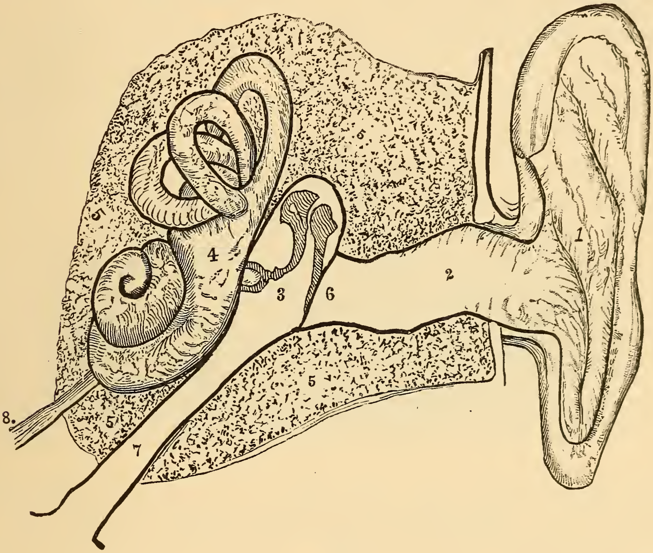


Fig. 87.

Diagram of Left Ear.

1, concha; 2, external canal; 3, middle ear, crossed by the ossicles; 4, inner ear, showing vestibule, semi-circular canals, and cochlea; 5, petrous bone; 6, external membrane of the middle ear; 7, Eustachian tube; 8, auditory nerve.

the petrous bone and is lined with skin. It is an air chamber about one fourth of an inch in diameter, and an inch long, and conducts the sound toward the inner ear. The inner end of this canal is closed by a membrane, which is stretched tightly across it. This canal is called the *external auditory canal.*

The middle portion of the ear is called the *tympanum.* It is an air chamber in the petrous bone, about as large as a small cherry, and conveys vibrations from the outer to the inner ear. Its outer wall is formed by a thin membrane across the end of the external canal. This is called the *external membrane of the tympanum.*

A second membrane closes the passage between the middle and the inner ear. The outer and the inner membranes of the tympanum are connected by a crooked line of bones, the smallest in the body, called the *ossicles* of the ear. They aid in hearing, by forming a better means of transmitting the waves of sound; yet they may be removed, and the hearing be retained. There are four in each ear, called from their shape (1) *the hammer*, (2) *the anvil*, (3) *the orbicular*, or *round bone*, and (4) *the stirrup.*

They are joined by cartilage, and are acted upon by small muscles that enable us to make the chain press firmly against the membranes, as we do in straining the ear to hear sounds that are difficult to catch. (See Fig. 87.)

A small air passage, called the **Eustachian tube,** leads from the tympanum to the pharynx. This is the only opening through which air can pass into or out of the middle ear.

By means of this tube, the air on both sides of the external membrane (see Fig. 87), being of the same density, has an equal pressure; and by its free ingress and egress at both throat and ear, permits of livelier and fuller vibrations of the intervening membrane. It is for the same reason that an ordinary drum is provided with an aperture at the side. If there were no Eustachian tube, violent concussions, and sudden and powerful vibrations of any sort, would tend to injure and break down the external membrane.

The inner ear is a very singularly shaped chamber in the petrous bone. This chamber consists of (1) an outer space, called the *vestibule*, (2) three *semi-circular canals*, and (3) a spiral part, known from its peculiar shape as the *cochlea.* The vestibule and the semi-circular canals are filled with a watery fluid, and have in them membranes on which the nerves of hearing are spread out. The cochlea, however, contains no water, but receives a special branch of the auditory nerve. On entering the cochlea this nerve spreads out into multitudes of fibers which fill the whole interior of this peculiar chamber. (See Figs. 88 and 89.) Near the membrane, against which the stirrup bone fits, the cavity of the inner ear is large. This large part seems designed to receive the ruder sounds.

The cochlea of the inner ear contains a thin, bony plate, triangular in shape, across which are drawn nerve fibers of different lengths, somewhat like the wires of the harp or piano. This portion of the ear seems designed for the appreciation of musical sounds. The inner ear is the most important part of the organ. The other portions may be destroyed, and yet we can hear quite well by this portion alone.

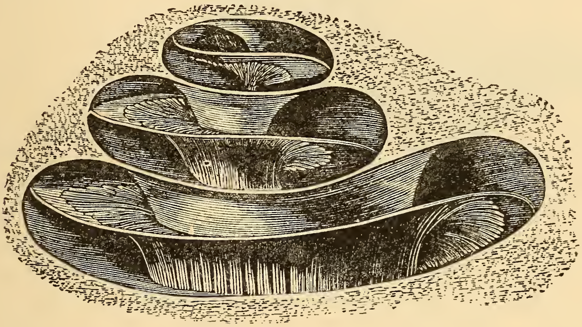


Fig. 88.

Cochlea without Nerve (magnified).

When any elastic body, such as a bell, drum, or piano string, is struck, it vibrates very rapidly. The air which surrounds the vibrating, or sounding body, is elastic too, and is caused to vibrate as the bell does. The vibrations in the air pass out from the bell in all directions in waves.

If these waves are continued to the ear, they will affect the nerves of hearing so as to produce those sensations on the brain that the mind learns to know as **sound.** By practice, the mind learns much about the nature of the sounding body, its direction, and something about its distance. The objects which produce the sounds we hear do not come into the ear and touch the nerves of hearing, but sound comes from them into the ear, somewhat as light comes into the eye.

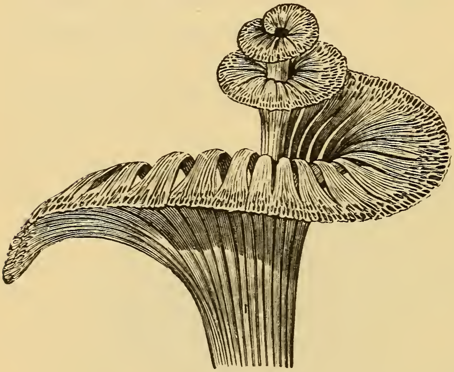


Fig. 89.

Auditory Nerve of Cochlea, removed from its Bony Case.

Hygiene of the Ears.—The ear is more liable to disease than the eye is. It is sometimes injured by the lodgment of objects in the outer ear. The bitter wax of the outer ear is designed to protect the ear from insects. This should not be artificially removed; it will come out of itself. Inflammation of the throat often affects the ear through the Eustachian tube. The ear should not be exposed to great cold, nor to draughts of cold air. Under no circumstances should any one be struck on the ear; this is liable to injure the tympanum seriously.

Deafness is a very great misfortune. In losing the hearing the mind loses one of its chief organs of sense. It is through hearing that we learn to use language. Any one who is born deaf, is also dumb. Any one who loses the sense of hearing, soon loses the power to modulate the voice, for the voice is guided by the ear. In some cases, those who become deaf grow weak in mind.

QUESTIONS.—1. Where is toothache really felt? Why does the removal of an aching tooth give relief? If a nerve of sensation is cut, can there be any pain from its extremity? What is ordinary sensation? Upon what does acute sensation from any part depend? How is pain useful to us? How may the relative sensitiveness of different parts of the skin be measured?

2. Is pain a special sensation? How many, and what are the special senses? What common end is served by all of them? What are the organs of the special senses? Where do the nerves supplied to each lead?

3. What four senses have their organs in the head? What special class of nerves is supplied to all of them? In what part of the body is the sense of touch most useful to us? Describe the papillæ of the skin. Some general uses of the hand. What do you recall about the number of its bones and joints? Which of the other senses coöperates most actively with the hand's touch in adding to our knowledge? Describe the outer extremities of the nerves of touch. How does this sense aid the blind?

4. Has the tongue any nerves of touch? Which does the tongue do first—taste, or touch? Can a dry hand feel? Can a dry tongue taste? What parts of the tongue are most sensitive to taste? Name some important uses of this sense. What cartilage at the back of the tongue? What bone at its base?

5. What sense is most intimately related to that of taste? Through what nerve does the brain receive sensations of smell? In what part of the nasal cavities are the branches of the olfactory nerve? Name some uses of this sense. Why does inspiration through the nose increase our perception of odors?

6. What does sight tell us about objects? Describe the situation of the eyes. How are they protected from blows? From dust? From excessive light? What gives firmness to the eyelids? Where are the lachrymal glands? The lachrymal canals? What are their uses? What other glands are there in the eyes? How are these organs moved?

7. How many coats has the eye? What does *sclerotic* mean? Describe the sclerotic coat. Where is the cornea? Is it white? Name and describe the middle coat. What is the *iris*, and why is it so named? With what other part of the eye does it correspond in circumference? Which of these parts—iris and cornea—has motion of its own? Describe the retina. How may we see that the choroid coat is black?

8. What substance forms the greater part of the whole globe of the eye? Between what parts of the eye is the aqueous humor? What humor separates the aqueous humor from the vitreous? What optical characteristic is common to water, crystal, and glass? What does *retina* mean?

Why should the name be given to the inner coat of the eye? What cranial nerves are concerned in vision?

9. Do we know what light is? Tell, in your own language, how pictures are formed on the retina. Is this process artificially imitated? What is the "blind-spot"? How may you demonstrate that it exists? What does this proof show you as to its position on the ball of the eye? Are the pictures on the two retinas exactly alike? Do these pictures differ from each other horizontally, or vertically? Why?

10. On what surface are the rays of light from an object brought together in perfect vision? What is the shape of the crystalline lens? If in any case it is too convex, what results? What artificial lens is used in near-sightedness? If the crystalline lens is not convex enough, how may we correct the fault? Is the cornea a lens? Give some rules for the care of the eyes.

11. Why is the *concha* so called? What is the use of it? Is any part of the outer ear inclosed in bone? Name the four smallest bones of the human body. What title have they in common? How many and what, are the air chambers of the ear? How does air pass in and out of the tympanum? What parts of the ear contain water? What inner chamber contains no water? Describe the cochlea. What is the origin of this word? Where is the vestibule? What separates the vestibule from the stirrup bone? What is sound? Give some simple rules for the care of the ear.

CHAPTER XIII.

THE VOICE.

Etymology of Terms.

är tic ū lā'tion (Lat. *articulus*, a little joint); hence, the jointing together of syllabic elements.

côrd (Gr. *chordē*, the material from which musical strings were made).

g̃lŏt'tis (Gr. *glōtta*, the tongue); hence, the vocal passage that is just back of the tongue.

tĕnse (Lat. *tensum*, stretched), strained stiffly.

1. The voice is produced by the vibration of cords that are situated in the **larynx.** The larynx is in the upper part of the neck, and forms the air-passage from the pharynx to the trachea. The large prominence that may be seen or felt just beneath the lower jaw, on the front of the neck, is the larynx. It is familiarly known as the "Adam's apple." (See Fig. 90.) It is a cartilaginous box, about two inches long, and more than an inch in breadth. It is suspended from the hyoid bone (see p. 44) by a broad ligament and by muscles. Its walls are formed of four plates of cartilage that are fitted movably upon one another, so that we may read-

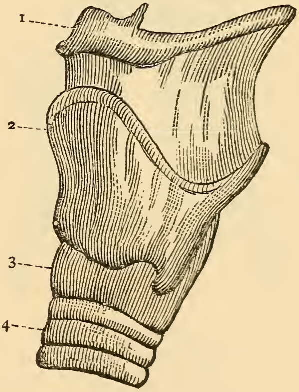


Fig. 90.

External View of the Left Side of the Larynx.

1, front portion of hyoid bone; 2, upper edge of larynx; 3, lower portion of larynx; 4, second ring of trachea.

ily change the shape and size of the larynx by moving its muscles and ligaments. The cartilaginous plates shield the delicate, movable structure from external injury, and give resonant firmness to the walls of the larynx. The voice also derives resonance from the open spaces of mouth and nose, and from the cavity in the frontal bone of the skull.

2. The interior of the larynx is lined with mucous membrane, which is very sensitive, so that violent coughing is excited if anything touches it. The larynx is closed at the top by the *epiglottis* (see p. 140), a long piece of cartilage that is attached to the base of the tongue. This closes over the larynx while we swallow, but at other times is raised, so that the larynx is open for the passage of air to and from the lungs.

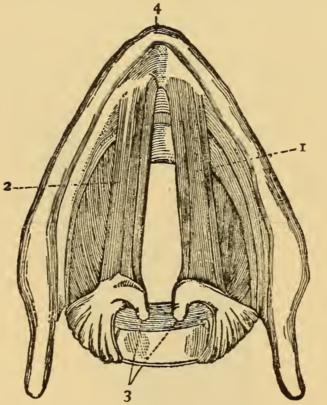


Fig. 91.

CROSS-SECTION OF THE LARYNX ABOVE THE VOCAL CORDS.

1, right vocal cord; 2, left vocal cord; 3, cartilages to which the vocal cords are attached behind; 4, front edge of the larynx.

The vocal cords, by which the sounds of the voice are made, are within the larynx. They are not strings, but are simply folds of the mucous membrane that lines the larynx. These folds are on the sides of the larynx. There are four folds, or cords, two above (one on each side), called the false cords, and two below (one on each side), called the true cords because it is by the vibration of the lower ones only that sound is made. Their edges are firm, smooth, and quite sharp. When vibrating to produce sound they nearly meet across the larynx. (See Fig. 91.) The narrow, slit-like opening between the vocal cords is called the *glottis.* It runs from front to rear, and is less than an inch in length.

3. During ordinary breathing, no sound of the voice is made; in such cases, the cords are not stretched tightly across the opening of the larynx, but are relaxed at one end, leaving the glottis, shaped like the capital letter V (see Fig. 91), through which the air passes without obstruction. In order to make a sound, we draw the cords closely together, so as nearly to close the passage through the larynx. Their edges almost touch, and are thin and tense. While in this condition, we force the air between them, thus making the edges of the cords vibrate very rapidly. **The vibrations of the cords** and of the air surrounding them **produce sound.**

We change the *tone* by the way in which we stretch the cords, and by the size and shape we give to the larynx and mouth. If the cords are drawn tightly, they vibrate rapidly, producing an acute sound; when they are relaxed they are thicker, and produce a graver sound.

The *loudness* of the voice depends upon the force with which the cords are caused to vibrate, and this, in return, depends almost wholly on the force with which the breath is driven out of the lungs. To have a full, round, strong voice, one must have a strong chest and diaphragm, and must speak with plenty of air in the lungs. The longer the cords, and the larger the larynx, the deeper will the voice be.

The *quality* of the voice, or that peculiar property of it by which we recognize the utterance of a particular individual, depends upon the shape of the chest, trachea, larynx, and the cavities of the nose and mouth.

The articulation of sounds, by which we are enabled to speak, is not a function of the larynx, but of the various parts of the mouth and throat.

The *volume* of the voice may be very greatly developed by proper exercise and training of the vocal organs. Any one who will give the lungs their natural freedom and will breathe deeply and fully, may speak in a loud tone. The weak voice is usually indicative of inefficient breathing. Purity of tone may be greatly improved by intelligent practice. Singing and reading aloud are excellent exercises for developing the voice. The lungs, too, will gain in power. One who sings or speaks much will not be likely to suffer from weak lungs.

QUESTIONS.—1. What air-passage is just below the larynx? How large is the organ of voice? Of what substance are its walls composed? Do you recall any reason for the firmness of the walls of the trachea? What reason, besides this, is there for the cartilaginous structure of the larynx? Where else does the voice gain resonance? What does *resonance* mean? What tube lies immediately back of the larynx? To what bone is the larynx attached?

2. Describe the inner lining of the larynx. How is food kept out of this air-passage? Why is the epiglottis so named? What are the vocal cords? How many of them are properly so called? What is the name of the opening between the true vocal cords?

3. How is voice produced? In what way does the diaphragm aid in the process? What effect upon the tone of the voice has the shortening of the vocal cords? What gives loudness to the voice? Where is speech articulated? How may the volume and vigor of the voice be developed?

CHAPTER XIV.

VENTILATION.

Etymology of Terms.

cŭr'rent (Lat. *currere*, to run).
flūe (Lat. *fluere*, to flow); hence, an air-passage.
pär tĭ'tion (Lat. *partitio*, a part).
rĕġ'is ter (Lat. *re*, back, and *gerere*, to carry).

1. Having learned the hygienic principles in relation to the various organs of the body and to the performance of their proper functions, it still remains to consider the general hygiene of the home and surroundings.

The proper ventilation of houses is one of the most important factors in the health of their inhabitants.

The dust, gases, etc., incident to housekeeping tend to deteriorate the air, and the fires and lights deprive it of its vital qualities, while we ourselves are constantly consuming the oxygen which it contains, and conveying to it matter which it is poisonous for us to breathe. It is therefore evident that two things are necessary: first, to get rid of the impure matter in the air of a room; and second, to supply it with pure air to take its place.

2. The air is composed chiefly of three gases, viz.: oxygen, nitrogen, and carbonic acid gas. Of these three gases, the oxygen is the most important so far as human life and health are concerned.

Dr. Hunt thus sums up the conditions which render the air in houses unfit for breathing:

"(1) The undue deficiency of oxygen and undue increase of carbonic acid gas.

(2) The addition of ammoniacal and other nitrogenous products, and of various gases of imperfect combustion.

(3) The addition of dusts and of various particles of an animal, a vegetable, or a mineral nature, some of which irritate in their processes of growth and decay, and some of which irritate mechanically.

(4) Such heat and dryness of air as causes it to make too great demands upon our bodies for moisture.

(5) Such heat and saturation with moisture as prevents the air from readily taking up the perspiration or other secretions of our bodies.

(6) Such sudden changes of air as expose us to draughts, and to such changes in temperature or in perspiration as produce colds, irritation, or congestion in parts of the system.

3. The subject of ventilation deals with the methods of **overcoming** these conditions in the most efficient way. To do this, the ventilation must conform to the following conditions:

(1) The air which is introduced into the rooms must be **pure**—*i. e.*, it must be as free as possible from extraneous matter, and it must contain, in the right proportion, the gases above enumerated; in other words, it should approach the standard of purity in the external atmosphere. As the air near the ground is not likely to be pure, it is better to introduce the air into the house from a few feet above the surface.

(2) Attention should be paid to the **quantity** of fresh air admitted. According to an eminent authority, we need at least two thousand cubic feet per hour.

In cases of sickness, especially, ventilation is of great importance to remove the organic matter thrown off, and the quantity of fresh air should be unlimited. (See p. 233.)

(3) Great care must be taken that the **temperature** of the air in the room is neither too warm nor too cold, as the

former condition is liable to cause headache, and the latter, colds. The proper breathing temperature is from 60° to 70° Fahrenheit.

(4) **Prevent Draughts.**—A draught is caused by a difference in temperature between the air in different places. When the air in a room is warm and that outside cold, the opening of a window is apt to cause a draught. It is necessary to secure the needed change of air, and yet to introduce the air in such a manner as to avoid dangerous draughts.

The facility with which this may be done depends on various conditions :

First. The *temperature* of the air in the room as well as of that outside.

When the temperature of the external air is warm, there is not so much risk from draughts; but in cold weather, when we need heat in the rooms, the air must not be allowed to enter with too much draught.

Second. The *way* in which the air is introduced. More draught is likely to occur when the air is admitted only at one or two points in large quantities than if it is introduced at several points in smaller quantities.

Draughts are also avoided by introducing the air above the head in such a way as to give it a slight ascent. This may be done by having a piece of board or strong cloth, cut so that it shall be four inches wide, and just as long as the window-sash is wide. Raise the lower sash four inches, and fasten this board under it by a button or some other arrangement, so that the opening will be entirely closed by the board and no air can enter at the bottom. The only space for the air to enter will be at the middle of the window, between the upper and lower sashes. The air is thus obliged to travel upwards. The air in entering the room then blows upwards toward the ceiling and gradually mingles with the other air of the room. Another way to accomplish this end is to have double windows.

Third. The *size* of the room. In a small room, the air may not have time to be distributed before reaching the person, and so may cause a draught.

Fourth. The number of people occupying a room. The greater the number of people in a room, the more rapidly must the air be introduced.

4. Ventilation is either attained by **artificial** or by **natural** means. In systems which are distinguished by the general name of mechanical or artificial ventilation, special provision is made for driving the air by fans, by furnaces, or by other contrivances.

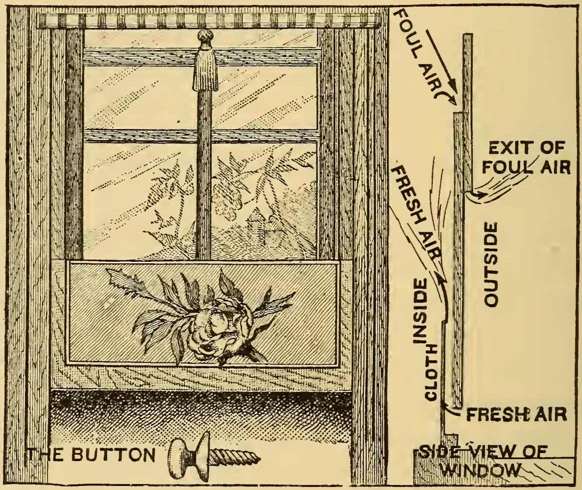


Fig. 92.

Board attached to Window for Ventilation.

In natural ventilation, no special appliance is used to give motive force. This includes ventilation which takes place through the porous walls of buildings, through cracks, windows, and doors ; and that afforded by fires used for heating.

The chief agent in domestic ventilation is the *chimney.* The hot air in the chimney is lighter than that outside.

This supplies a motive force, compelling the air to enter at the bottom through the grate, and causing a current to ascend.

In providing for *artificial* ventilation, it must be borne in mind that the three main things necessary are (1) an inlet or inlets for the air; (2) an outlet or outlets, and (3) a motive force to produce and maintain the current.

There are so many methods of artificial ventilation that it is impossible to describe them here. The following general directions, as quoted from Dr. J. S. Billings, may, however, be found useful:

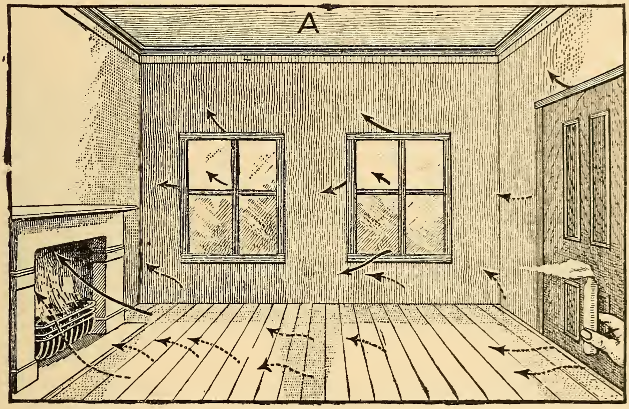


Fig. 93.

VENTILATION, WINDOW CLOSED.
Flame at key-hole horizontal.

"*First.* The register must be in such a position, and of such a size, that the requisite amount of air can be introduced through it without causing currents of air of such velocity as will cause discomfort to the occupants of the room. The only difficulty in this respect occurs in rooms occupied by a number of persons, such as assembly and school-rooms, churches, theaters, hospitals, etc. Under such circumstances, it is sometimes very difficult to so locate the fresh-air registers that the currents therefrom will not be unpleasantly perceptible if they are rapid, and it then becomes necessary to make these registers of such an area that the velocity of the inflowing air need not exceed one and a half feet per second to secure the introduction of an amount sufficient for both warming and ventilation. When the registers are so situated that the currents from them will produce no discomfort, they may be made smaller. For example, if it be determined to introduce the fresh air directly through a perforated floor in an assembly room, the total area of openings should be at least one hundred square inches for each occupant, while the area of register openings need not be more than forty square inches for each occupant, if they are placed near the ceiling.

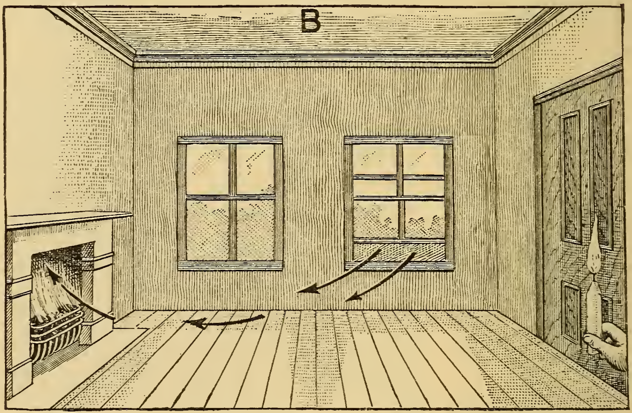


Fig. 94.

Ventilation, Window open.
Flame at key-hole in repose.

Second. Taking it for granted that the fresh air is to be warmed in cold weather before it is brought into the room, its registers must not be placed below the foul-air registers, unless the former are scattered near the floor of the room. The reason for this is, that direct currents between the inflow and outflow registers are easily established when the latter are above the former, and in such case little change is effected in the great mass of the air in the room.

Third. Flues of proper size can not usually be placed in thin walls, such as ordinary interior partitions. A flue measuring less than five inches in its smallest diameter is of little use. Fortunately, in ordinary dwelling-houses, where this difficulty of thin partition walls is greatest, the precise location of fresh-air and foul-air flues is of minor importance, so long as the precaution advised in the preceding section is observed.

Fourth. Fresh-air registers should not be placed in a floor so as to be flush with its surface, because dust and dirt will fall into the flues and be returned, to a certain extent, in the column of ascending air. Such registers are also a fruitful source of loss of small articles. It is always possible to continue the flow upward into a step or seat, and then place the register in the side of this.

There is less objection to placing foul-air registers in the floor ; but even this should be avoided, unless the openings are covered by some article of furniture, as, for instance, in a hospital ward, where a good position for the foul-air registers is in the floor beneath each bed ; and even then the register should not be flush with the floor, but rise an inch or two above its surface.

Fifth. In dwelling-houses and buildings of moderate size, it is economical to centralize the heating apparatus as much as possible, keeping the fresh-air flues in inner walls ; but it is not easy by this method to secure sufficient warmth in the vicinity of windows, especially on the side most exposed to the winter winds.

On the other hand, hot-air flues should not be placed in outer walls, unless these are thick and substantial, and even then it will be good economy to make the flue of terra-cotta or galvanized iron, so set as to leave an air-space of an inch or two on the other side. For rooms on the floor immediately above the radiators, it is not necessary to place flues in the walls in order to bring the registers under or near the windows, which is their best place, so far as heating is concerned. Foul-air flues should not be placed in outer walls, unless they are to be carried downward and to have some means of aspiration connected with them.

Sixth. General Morin, and the majority of modern French engineers, advise that the place of introduction of fresh air shall be near the ceiling, in order to avoid unpleasant currents, while the discharge openings, on the contrary, should be near the floor. The introduction of warm air near the ceiling, in order to prevent disagreeable currents, is not absolutely essential, for such currents can be avoided, as above explained, by making the registers of proper size; and to secure comfort in cold weather, it is necessary, on this plan, that the air shall be introduced at a temperature several degrees higher than is required if it be admitted at a lower level.

The proper position of the foul-air registers depends on the purpose of the room and on the season. During cold weather, in the majority of cases, they should be near the level of the floor, to secure a satisfactory distribution of the air with the least expense. In large assembly-halls, however, and especially where it is desired to provide air as pure as possible for respiration, instead of foul air diluted to a certain standard, the discharge openings should be above.

Seventh. In order to secure a thorough distribution of the incoming air, it is usually recommended that the discharge openings should be in the side of the room opposite to that in which the fresh-air openings are placed, and as far as possible from them.

In all dwelling-houses, however, and in rooms not having windows on opposite sides nor containing a sufficient number of occupants to exercise any special influence on the temperature, good ventilation will be secured by placing the fresh warm-air openings on an inner wall, and the discharge openings in the same wall at the same or a lower level. This is the arrangement in most dwellings heated by indirect radiation, the fresh-air register being in the side of the chimney near the floor, and the foul air passing out through perforated fireboards on the same level a few feet away. The result is the establishment of a circulation from the fresh-air opening upward and along the ceiling to the outer walls and windows, thence down the wall to the floor, and along the floor to the discharge.

But when we come to deal with rooms having a large floor area in proportion to the height, and containing fifty or more persons, whose heat production is a factor that must be taken into consideration, there is some danger by this method, that there will be an unsatisfactory distribution of the fresh air when the temperature of the external air is not below 50° Fahrenheit."

QUESTIONS.—1. Why is ventilation absolutely necessary? What substances tend to pollute the air? What are the important principles involved in the question of ventilation?

2. What is the composition of the air? What conditions render the air in houses unfit for breathing?

3. By what means may these difficulties be overcome? What should be the quality of the air introduced? What quantity is needed? In what cases is ventilation of the greatest importance? What should be the temperature of the air? What is the cause of draughts? How may they be prevented? Describe an arrangement attached to the window designed to accomplish this end.

4. What are the two methods of ventilation? What other name is applied to artificial ventilation? What contrivances are used for artifi-

cial ventilation? For natural ventilation? What is included under the term *natural ventilation?* What is the chief agent in domestic ventilation?

In providing for artificial ventilation, what three points should be considered? Give briefly Dr. Billings's general directions for artificial ventilation.

CHAPTER XV.

WATER IN RELATION TO HEALTH.

Etymology of Terms.

ȼŏn tăm i nā'tion (Lat. *con*, with, *tangere*, to touch).
ĕr y ṣĭp'e las (Gr. *eruthros*, red, and *pella*, skin).
ġē ō lŏġ'i ȼăl (Gr. *ge*, the earth, and *logos*, science).
pĕr'ȼō lāte (Lat. *per*, through, and *colare*, to strain).

1. The immediate **sources** of water supply are the rain, springs, wells, rivers, and lakes.

Rain water, when uncontaminated by impurities, is healthy and pleasant ; but in many cases it contains a large amount of organic matter, and is then less pure than water derived from deep wells and springs.

Water from Wells, Springs, Rivers, and Lakes.—The quality of the water derived from these sources depends on the nature of the soil and geological strata through which it has passed, and on the character of its surface bed or channel. The rain, already charged with carbonic acid in its passage through the lower regions of the atmosphere, becomes still more impregnated with this gas when it sinks beneath the surface.

2. Surface or shallow-well waters, though sometimes comparatively pure, may contain a large amount of organic matter, and should therefore be well filtered before being used.

3. The waters from **deep wells** and springs vary according to the geological strata through which they pass.

Some of them are very pure, while others contain large amounts of mineral or organic matter.

4. River water is usually softer than spring or well water. It does not contain a great amount of mineral salts, but usually receives much organic matter from the vegetable *débris*, etc., which find their way into it. Its constant movement and the plants which inhabit it tend to purify it.

5. Lake water generally contains very little mineral matter, but the organic matter from deposits is usually considerable.

Dr. Nilson thus classifies the various waters in respect to their wholesomeness, palatability, and general fitness for drinking and cooking :

Wholesome	1. Spring water	Very palatable.
	2. Deep-well water	
	3. Upland surface water	Moderately palatable.
Suspicious	4. Stored rain water	
	5. Surface water from cultivated land	Palatable.
Dangerous.	6. River water to which sewage gains access	
	7. Shallow-well water	

According to softness :

1. Rain water.
2. Upland surface water.
3. Surface water from cultivated land.
4. River water.
5. Spring water.
6. Deep-well water.
7. Shallow-well water.

6. Impure Water.—Water may be rendered impure by an excess of *mineral* substances, and by the presence of *vegetable* or *animal* organic matter.

Waters of a moderate amount of hardness, provided the hardness depends chiefly on the presence of calcium carbonate, are not detrimental to health.

The symptoms arising from an excess of hardness, due to the presence of earthy salts, are mainly of a dyspeptic nature. Iron, when present in large quantities, produces *headache* and *dyspepsia*. Lead often causes lead-poisoning. Arsenic, copper, or mercury are not usually found in drinking water except when the streams receive the washings of chemical works, mines, etc.

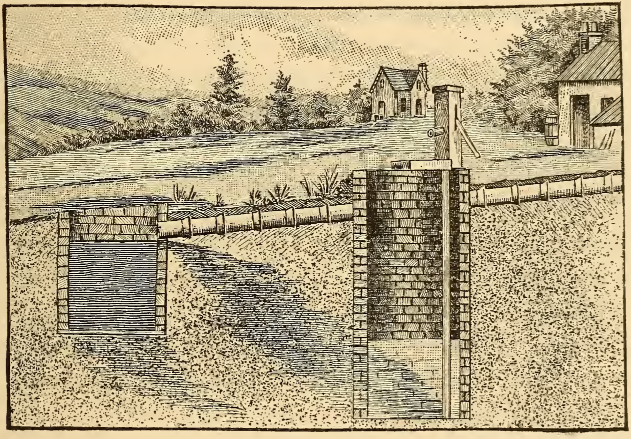


Fig. 95.

How Water is contaminated by Sewage.

Vegetable matter found to any extent in water renders it unwholesome. It is likely to cause *ague* and other malarious ailments.

The most dangerous impurities found in water are those due to *animal organic matter*. The presence of decomposing animal matter, whether it has percolated through the soil from cesspools, or whether it has been discharged from open sewers into streams and rivers, converts drinking water into a dangerous poison, fraught with disease and death. The principal diseases which are due to such impurity of water are: *cholera*, *enteric fever*, and *dysentery*.

In Fig. 95 the cesspool is represented as full and overflowing into a well.

These are the direct ways in which impure water proves an evil and danger to a community, but it may also do harm in an indirect way. For instance, where the water supply is scanty, there is likely to arise lack of cleanliness in person and surroundings; while overcrowding, defective sewage removal, badly ventilated drains, and other causes may coöperate in affecting the health of a community.

Among other diseases primarily due to the condition of the water may be mentioned *erysipelas*, *low fever*, and *ulcerated sore throat*.

7. Purification of Water.—Water that is cloudy in appearance is often improved by the use of a filter to remove the minute particles. The water is brought into contact with the air which enters through small openings, and some oxidation of organic matter takes place. The greatest water filter is the earth itself, through which the surface and rain water passes.

There are various forms of filters for the house. Granulated animal charcoal, through which water is filtered, improves its quality. Flannel tied on the faucet will strain out much organic matter. Filtering paper may also be used. One of the latest methods employed consists in passing the water through a slowly revolving cylinder containing metallic iron in the form of scraps or filings.

The following suggestions, by Dr. Parkes, are very practical:

"Get a common earthenware garden flower-pot; cover the hole with a bit of zinc gauze or a bit of clean-washed flannel, which should be changed from time to time; then get some rather small gravel, wash it very well, and put it into the pot to the height of three inches ; then get some white sand and wash it very clean, and put that on the gravel to the height of three inches ; then take two pounds of animal charcoal, wash that also by putting it into an earthen vessel and pouring boiling water on it ; then, when the charcoal has subsided, pour off the water, and put some more on for three or four times. When the charcoal has been well washed, put it on the sand and press it well down. Have four inches of charcoal, if possible. The filter is now ready. Pour water into the pot, and let it run through the hole into a large glass bottle.

After a time the charcoal will get clogged ; take off a little from the top and boil it two or three times, and then spread it out and let it dry before the fire. It will then be as good as ever. From time to time all the charcoal and the sand also may want washing. The sand may be put over the charcoal, and not between it and the gravel ; but this plan sometimes leads to the charcoal being carried, with the water, through the gravel and out of the hole. The sand stops it.

By filtering in this way, and by boiling the water, many dangers are done away with."

Where the water is very impure, it is well to boil it before using it for drinking purposes.

QUESTIONS.—1. What are the immediate sources of water supply? When is rain water pure? When is it impure? On what does the quality of water depend?

2. Describe shallow-well water. Why is it likely to be impure?

3. How do the waters from deep wells and springs vary? What can you say about their purity?

4. Describe river water. How does it compare with spring and well water? What conditions tend to purify it?

5. Describe lake water. Which of these various waters are the most wholesome? Which the softest?

6. What three conditions tend to render water impure? What symptoms arise from an excess of hardness in water? What evils are produced by the presence of iron? By the presence of lead? What is the effect of vegetable matter in water? What diseases are caused by its presence? Why are animal impurities the most dangerous? What diseases are caused by their presence in water?

7. By what means is water purified? What is the greatest water filter? Describe some forms of domestic filters.

CHAPTER XVI.

DWELLINGS.

Etymology of Terms.

ĕx ca vā′tion (Lat. *ex*, out, and *cavare*, to make hollow).
por′ous (Gr. *poros*, a passage).
rĕf′use (Lat. *re*, back, and *fundere*, to pour).
sīte (Lat. *situs*, placed).

1. Great consideration should be given to the sanitary conditions of dwellings, as diseases frequently arise from unhealthy sites, from insufficient ventilation or overcrowding, from tainted water supply, from defective drainage, etc.

2. Site.—In choosing a site, special attention should be paid to the nature of the soil and the conformation of the ground. The soil should be dry, or in such condition that there will be no difficulty in respect to efficient drainage.

The permanent presence of water in a soil upon which a dwelling is built, or the presence of standing water near it, is very often a source of some of the most fatal diseases. If, therefore, the soil is in the least degree damp, it should be thoroughly drained by means of tiles or ditches. Very frequently a piece of ground which appears dry may be in reality saturated with moisture. The best situation is on rising ground, with trees in the immediate neighborhood.

When possible, it is well to build the house *near* the woods, which will serve as a screen from the cold winds; but under no circumstances should the house be built *in* the woods where the sunshine is excluded.

In towns, a great evil sometimes arises from building on rubbish containing vegetable matter which has been used to fill up excavations.

It is preferable that a house should face east or southeast, because in the morning the rays of the sun penetrate to the front rooms, and in the afternoon to the back. When a house faces the south, the front rooms are overheated in summer by the rays of the sun at noon, while those of the back are deprived altogether of sunlight.

3. After the site has been selected with care, the **structural arrangements,** plumbing, etc., require consideration. The general direction that these matters should be placed in the hands of a competent man will suffice at this point.

4. The Removal of Waste Matter.—The term sewage may be used to include all the refuse which is constantly accumulating in inhabited places, and requires to be removed if cleanliness and health are to be maintained.

In every process of life there is constant production of refuse. All organic nature about us is undergoing the same process. If this waste matter is left to decompose, to taint the air, and to pollute the water and the soil, it becomes a source of danger and is likely to occasion diseases of various kinds.

It should therefore be a fixed principle with every householder to see that all the waste substances of the house shall be removed in such a way that they can not get back in any way, whether in solution in the water we drink or in the air we breathe.

Many of the drains used for carrying away waste matters are harmful rather than beneficial as they should be. Apparently they remove the waste matters, but in reality they keep them near us, and thus often cause disease and death.

A drain should not be made too large, as the current in a large drain is not so swift, and there is danger of the adhesion of the waste matter to the sides of the drain, and a consequent generation of unhealthy gases, and a tendency to stoppage. In a smaller drain, the swifter flow of the current sweeps the matter away. A drain of five inches in diameter is large enough for an ordinary house.

Drains should not be made of porous material, nor should they have loose joints which will allow leakage of gases or fluids. The best materials are metallic pipe and tile. There should be a constant and abundant supply of water running through the drain, or else the drain should be flushed at frequent intervals. If the drain is constructed on a slope, the contents will be more rapidly and readily carried away.

However, with the best of arrangements.and the utmost care, more or less of the waste matter will adhere to the sides of the sewer and of the drainage pipes, and this matter will give rise to poisonous gases. It is therefore necessary that the drainage pipes in the house be in communication with the outer air which consumes these matters. It is also of the utmost importance that care be taken that none of the gases can escape from the drainage pipe into the rooms of a house.

The three natural methods of removing waste matter upon which all artificial contrivances are based, are: water, ventilation, and combustion.

QUESTIONS.—1. Why is it necessary to carefully consider the nature of a dwelling place? What evils result from improper selections?

2. What factors must be considered in choosing a site? What should be the nature of the soil? If damp, what is the first step to be taken? What is the best situation? Why is it well to build near trees? What mistake is often made in building in towns? What is the best direction for the house to face?

3. What is the next question of importance? Why should the structural arrangement of the house receive careful consideration?

4. Why should all waste matter be quickly removed from a house?

By what methods may this be accomplished? Why do many of the drains designed for removing waste matter do more harm than good? What are the disadvantages of a large drain? The advantages of a smaller drain? What is the best sized drain for ordinary purposes? Why is an ample supply of water to the drain of great importance? What are the three natural methods for removing waste matter, on which all artificial contrivances are based?

CHAPTER XVII.

EMERGENCIES AND ACCIDENTS.

Etymology of Terms.

ăm'bū lance (Lat. *ambulare*, to walk), a walking hospital.
ăp'ō plĕx ȳ (Gr. *apoplessein*, to cripple by a stroke).
ăs phȳx'ĭ a (Gr. *asphuxia*, without beating).
ȼon tū'sion (Lat. *con*, together, and *tundere*, to crush).
pŭnȼ'ture (Lat. *punctura*, a prick).
tour'nĭ quĕt (French *tourner*, to turn).
vĕn'o mous (Lat. *venenum*, poison).

1. So many lives are lost by a failure to apply simple remedies in cases of accident which require immediate action, and where the loss of time involved in sending for a physician would be fatal, that it would be well to study carefully a few suggestions as to the care of the injured.

2. General Directions.—Do not forget that one of the first needs of a patient is pure air. If the accident occurs on the street, do not allow a crowd to accumulate; and if it occurs in the house, send all persons away from the patient's room except those who are needed to render assistance.

It is necessary that the injured person be examined with great care, as rough handling may aggravate the injury.

In case of any accident, send a message to the doctor, describing, as well as possible, the nature and urgency of the case, so that he may come prepared with all necessary appliances.

Ascertain whether or not the patient is unconscious. If there is complete unconsciousness, the arm when lifted and let fall offers no resistance and the various muscles act as dead weights. If the case is one of fainting, arrange the patient on his back, provide for his free breathing by opening tight clothes, etc., apply smelling salts to the nostrils or tickle them, and dash cold water on the face. In some cases, such as suffocation, it is necessary to establish artificial respiration. Fanning is often beneficial, and, where the patient is able to swallow, a few sips of a mixture of ammonia and water.

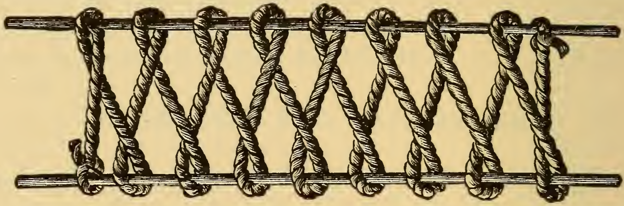


Fig. 96.

Rope Stretcher.

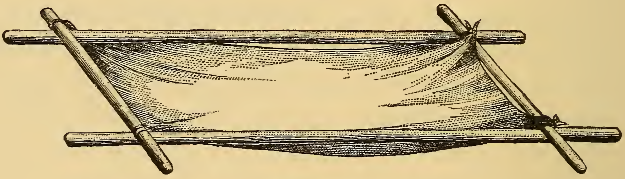


Fig. 97.

Stretcher formed by Four Poles.

If the accident occurs in a city where the ambulance service is established, no time should be lost in calling an ambulance. If this can not be done, a stretcher or some improvised chair should be used. Figs. 96 and 97 show two kinds of improvised stretchers.

3. Sunstroke and Exhaustion from Heat.—These conditions are caused by fatigue and exposure to heat. They most frequently occur in persons who are intemperate, physically weak, or not in good health. In sunstroke, the skin is hot, the pulse rapid, the patient breathes with difficulty, and is likely to be unconscious.

The patient should be placed on his back in a cool place, the clothing removed from head and chest, and cold water thrown over the body. Apply ice to the head.

4. Fractures and Dislocations.—It is a mistaken impression that a *fracture* must be set immediately. It will do less harm to leave it a short time without splints than to apply them awkwardly. Place the injured part in the least painful position, and keep the patient quiet until a surgeon can be obtained. Support the affected part in some way so as to prevent painful twitchings. In the case of a broken limb, elevate it slightly and apply cold water over the fracture, to keep the part from swelling.

In cases of *dislocation*, immediate action is of greater importance, as the muscular tension increases and the reduction then becomes more difficult. Dislocations of the fingers, except the thumb, can often be reduced by forcibly pulling them. In dislocation of the jaw, place the thumb on the back teeth and the fingers under the jaw. Depress the jaw forcibly, and at the same time lift the chin.

5. Sprains are serious injuries, and the most necessary thing is *rest*. While waiting for a surgeon the injured parts may be gently wrapped in hot or cold water.

6. Contusions and bruises result from falls, blows, or pressure, and when severe, are often followed by symptoms of shock. The best treatment is rest and cold applications.

7. Wounds.—In the case of all wounds there are five points to be attended to : (1) arrest the bleeding ; (2) clean the wound ; (3) bring the cut surfaces together ; (4) leave a way of escape for discharges ; (5) protect the wound from the air.

If wounds are made which bleed rapidly, pressure must be made on the veins or arteries that are cut. To do this, the wound must first be located. Pressure may be made with the thumb or with a knotted handkerchief tied around the limb and twisted by means of a stick until the bleeding ceases. This latter appliance is called a *tourniquet.* If the bleeding be from an artery, in which case it will come in jets of a bright red, the pressure must be made between the wound and the heart; if it is from a vein, make the pressure at or beyond the wound.

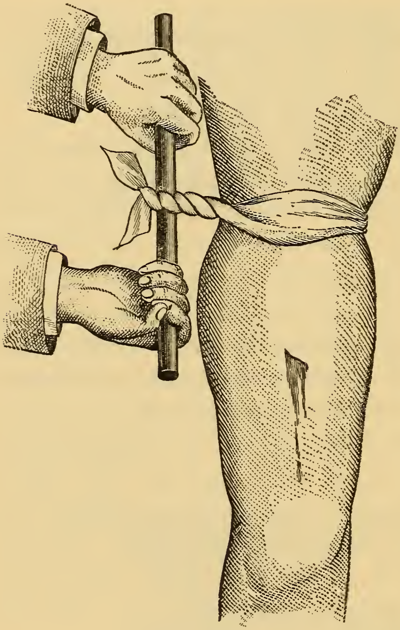


Fig. 98.

Application of an Improvised Tourniquet to Thigh.

Then wash the wound gently with water squirted from a clean sponge, dry it; place the edges naturally together with strips of adhesive plaster, and keep the wound quiet.

Wounds are likely to prove more dangerous when the patient is addicted to the use of alcohol, as all the organs of the body are impaired, and its natural healing forces thus weakened.

In a *punctured* wound, the first thing to be done is to keep it open till it heals from the bottom. If made by a splinter, thorn, piece of needle, or anything which has lodged in the skin, it is of the greatest importance that these substances be removed immediately, otherwise lockjaw is likely to result. If this can not be done readily by scraping, or by a simple incision, send for the surgeon at once, before the foreign substance has a chance to travel inward from the surface.

8. **Burns and Scalds.**—Cut the clothing quickly from about the injured parts, taking care not to open any blisters that may have formed. Immerse the injured part in cold water. Then cover it carefully with water and flour, or water and soda, or with sweet oil; keep the wound quiet. When blisters form, their contents may be removed by slight punctures with a needle.

If the clothing should catch fire, wrap the body in a shawl or blanket to extinguish the flames. If these can not be obtained, roll the patient on the ground, and wet the clothing.

9. **Starvation** may be relieved by at first giving very small quantities of food, at frequent intervals. Water may be given freely. The body should be kept warm.

10. **Choking** may be relieved by sharp blows on the back and shoulders, and by drinking cold water.

11. **Hemorrhages.**—Keep the patient quiet in a cool room, and when faint, in a recumbent position. In cases of nose bleeding, ascertain from which nostril the blood flows. Then compress the nostrils, raise the arm of the affected side above the head, and apply cold water to the forehead or back of the neck.

12. **Fainting.**—This is accompanied by unconsciousness occasioned by an insufficient supply of blood to the brain. Provide fresh air; keep the head as low or lower than the feet; apply water and smelling salts (ammonia).

13. **Frost Bite.**—Place the patient in a cold room, and rub the frozen or chilled parts with ice, snow, or cold water. Frost bites often prove fatal when the subject is a person addicted to the use of alcohol.

14. **Apoplexy.**—Loosen the clothing about the head, neck, and chest. Place the patient in a recumbent position, keep him quiet, and send for the doctor.

15. Foreign Bodies.—When foreign bodies, such as pins, crusts of bread, bones, etc., lodge in the *larynx*, they cause difficulty in swallowing and breathing, and give rise to the danger of suffocation. A sharp blow upon the back will sometimes be effective in removing the foreign body. If not, place the patient upon his head and move him from side to side, striking him between the shoulders with the open hand.

Any foreign body in the *eye* will occasion considerable pain. The secretion of tears will often wash out the cause of the trouble. If dust or cinders get into the eye, draw the upper lid down over the lower, and blow the nose violently. If the foreign substance is imbedded in the surface of the eyeball, call a surgeon at once.

Foreign bodies in the *ear* are often very troublesome, and if not removed may create inflammation, which may extend through the drum membrane to the brain. If the substance is hard, hold the ear downward, and syringe it gently with warm water, taking care not to close the opening. Send for the doctor as soon as possible.

Insects may be washed out by filling the ear with warm olive oil.

When a foreign body is in the *nostril*, let the patient take a full breath, firmly close the mouth and the unaffected nostril, and the air having no other way of escape, may expel the obstruction. If the object is in sight, compress the nostrils above the object and hook it out with a bent wire. Sometimes snuff will cause enough sneezing to dislodge the substance.

16. Venomous Bites.—In case of snake bites, or those from mad animals, the bleeding should be encouraged, not checked. Tie a handkerchief tightly about the limb just above the bite. Bathe the wound in warm water, and suck it, or apply cupping glasses before absorption takes place. Then cauterize the wound deeply and poultice it. In case of snake bites, stimulants should be administered.

Treat the bites and stings of insects with cool lotions. Be sure that the sting is not left in the wound.

17. Poison Ivy.—In cases of poisoning by poison ivy, treat the eruption with a strong solution of bicarbonate of soda.

(For treatment in other cases of poisoning, see pages 105 and 106.)

18. Intoxication.—Lay the patient on the side, with the head elevated, and administer emetics to induce vomiting. Slap the face or some sensitive part of the body.

19. Drowning, Asphyxia, Suffocation, Strangulation, etc.—Asphyxia is the name applied to the apparent death which is likely to occur from drowning or other causes. When a person is apparently drowned, the wet clothing must be promptly removed, and the body dried and well rubbed. Before beginning artificial respiration, the face should be turned down for a moment, and all accumulation of mucus removed from the mouth. In strangulation, remove all constriction from the neck.

In all these cases, as soon as possible, artificial respiration should be employed. The following directions are known as "Marshall Hall's Ready Method in Asphyxia":

First. Treat the patient *instantly on the spot*, in the *open air*, freely exposing the face, neck, and chest to the breeze, except in severe weather.

Second. In order *to clear the throat*, place the patient gently on the face, with one wrist under the forehead, that all fluid, and the tongue itself, may fall forward, and leave the entrance into the windpipe free.

Third. *To excite respiration*, turn the patient slightly on his side, and apply some irritating or stimulating agent to the nostrils, as *veratrine*, *dilute ammonia*, etc.

Fourth. Make the face warm by brisk friction; then dash cold water upon it.

Fifth. If not successful, lose no time; but, *to imitate* *respiration*, place the patient on his face, and turn the body gently, but completely, *on the side, and a little beyond;* then again on the face, and so on, alternately. Repeat these movements deliberately and perseveringly, *fifteen times only* in a minute. (When the patient lies on the thorax, this cavity is *compressed* by the weight of the body and *expira-*

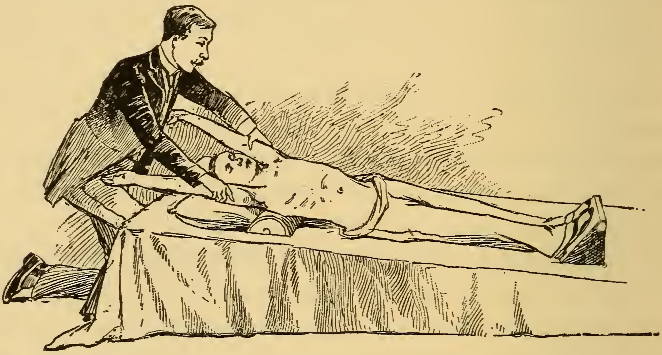


Fig. 99.

ARTIFICIAL RESPIRATION—INSPIRATION.

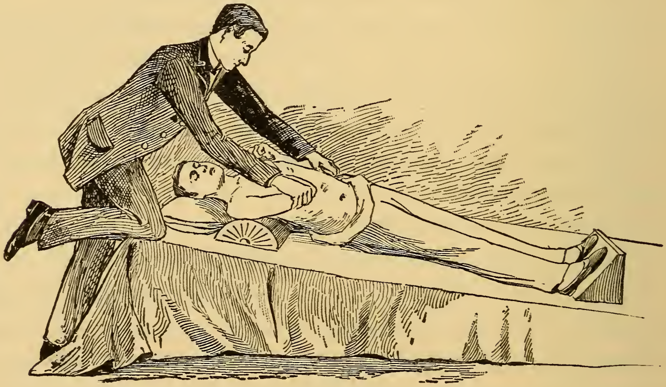


Fig. 100.

ARTIFICIAL RESPIRATION—EXPIRATION.

tion takes place. When he is turned on the side, this pressure is removed, and *inspiration* occurs.)

Sixth. When the prone position is resumed, make a uniform and efficient pressure *along the spine*, removing the pressure immediately, before rotation on the side. (The pressure augments the *expiration ;* the rotation commences *inspiration.*) Continue these measures.

Seventh. Rub the limbs *upward*, with *firm pressure* and with *energy*, the object being to aid the return of venous blood to the heart.

Eighth. If possible, substitute for the patient's wet clothing such other covering as can be instantly procured, each bystander supplying a coat or cloak, etc. Meantime, and from time to time, *to excite inspiration*, let the surface of the body be *slapped* briskly with the hand.

Ninth. Rub the body briskly till it is dry and warm, then dash *cold* water upon it, and repeat the rubbing.

Avoid the immediate removal of the patient, as it involves a *dangerous loss of time ;* also, the use of bellows, or any *forcing* instrument ; also, the *warm bath*, and *all rough treatment.*

QUESTIONS.—1. Why should we know how to act under emergencies? Is the saving of life always due to the physician's care?

2. What are the first steps to be taken in case of an accident on the street? What would you do in a case of complete unconsciousness?

3. To what is sunstroke due? What connection exists between sunstroke and intemperance? What are the symptoms? What should be the treatment?

4. Is it important that a fracture receive immediate attention? What can be done for the patient while awaiting a physician? What would you do in case of the dislocation of a finger? Of the jaw?

5. What is the most necessary condition to be procured in case of a sprain? What may be done while awaiting the arrival of the physician?

6. How are contusions and bruises produced? What is often the immediate result? Explain the treatment.

7. What five points would you consider in treating a wound? Why is pressure often necessary? Where and how should this be made? What other treatment is necessary? When are wounds most dangerous? What would you do in the case of a punctured wound?

8. What is the first thing to be done in case of a burn or scald? Give the treatment.

9. How may starvation be relieved? In what quantities should water be administered? What should the temperature of the body be?

10. How may choking be relieved? What effect has water in relieving this sensation?

11. In what condition should a person be kept in case of a hemorrhage? What treatment would you give?

12. By what is fainting always accompanied? To what is this condition due? How may it be relieved?

13. What should be done in cases of frost bite? Are hot or cold applications better? In what kind of patients do they usually prove fatal?

14. What is the first thing to do in case of apoplexy? What condition is absolutely necessary?

15. Where do foreign bodies usually lodge? What treatment would you give in case of a foreign body in the larynx? In the eye? In the ear? In the nostril?

16. Would you check bleeding in the case of a venomous bite? What treatment is given for snake bites? for stings of insects?

17. What is the symptom of poisoning by poison ivy? What treatment should be given?

18. What is the best position for an intoxicated patient? How may this condition be relieved?

19. What is meant by asphyxia? What is the first thing to be done to a patient apparently drowned? What artificial condition must be produced to relieve asphyxia, strangulation, suffocation, etc.? Give the method of inducing artificial respiration.

CHAPTER XVIII.

CARE OF THE SICK.

Etymology of Terms.

fer rṳ'ġĭ nous (Lat. *ferrugo*, iron rust).

ĭn ter mĭt'tent (Lat. *inter*, between, and *mittere*, to send).

pōul'tĭçe (Lat. *pultes*, thick pap).

pŭlse (Lat. *pulsum*, beat).

thẽr mŏm'e tẽr (Gr. *thermos*, hot, and *metron*, measure).

1. The recovery of a patient from illness often depends as much or more on the skillful care and nursing he receives as upon the medical skill applied; hence this subject becomes a matter of the greatest importance.

Nursing, in its widest sense, includes the careful and intelligent execution of the physician's orders, the administration of food and medicine, attention to the condition of the patient's room, its ventilation, cleanliness, and warmth, the careful observation of symptoms, the prevention of contagion, etc., etc.

The duties of a nurse are threefold: first, those which he owes to his patient; second, those due to the physician; and third, those which he owes to himself. Under the last category come especially those duties which relate to the nurse's health, since the nurse who takes the best care of his own health will be best able to care for that of his patient.

Whatever tends to keep the invalid quiet and contented is good for him; all excitement should be avoided. A tranquil, peaceful, and cheery atmosphere should prevail.

2. The Sick-room.—As more or less sickness is likely to occur in every household, and as the surroundings prove so great a factor in the rapid recovery of the patient, it is well, whenever possible, to have a room set apart for this purpose, specially arranged and ready to be used at a moment's notice. In selecting the room for this purpose, bear in mind the fact that it should be as remote as possible from the noise of the street. As a rule, a room at the top of the house is better, not only because it is furthest removed from the street, but because there will be no noise of footsteps overhead, the air is purer, and in case of contagious disease it is easier to isolate the person. The room should be large and have every convenience for ventilation ; it should be located on the sunny side of the house, as light and sunshine not only add to the cheerfulness of the room, but often serve as healthful stimuli.

In the furnishing of the room, the purpose in view should never be lost sight of. In a sick-room, more than anywhere else, cleanliness is an absolute necessity, and anything in the room which would render this condition difficult to attain is objectionable. First, as to the walls : it is better to paint than to paper them, even though the papering may be prettier. In the first place, wall-papers often contain arsenic or other injurious substances ; and, in the second place, in case of a contagious disease, it is always easy to thoroughly scrub a painted room, while a papered room, to be well disinfected, must have the paper torn from the walls, a troublesome operation.

In furnishing the room, it is better to have nothing superfluous. The essential things are bed, easy-chairs, lounge, and table. The best kind of bedstead is one made entirely of iron or brass with mattress of woven wire. Rugs are better than carpets, as they can be removed from the room and thoroughly shaken and cleaned. The furniture and wood-work should be free from all ornamentation in which dust is likely to lodge and to cause difficulty to remove it ;

for the same reason there should be no draperies or portières. Everything should be as simple as possible, but this does not imply that it may not be pretty and cheerful looking.

Under no circumstances should stationary wash-stands be permitted in a sick-room. The holes communicating with the drainage pipes are apt to emit injurious gases. When such wash-stands are found in or near the room, carefully cover all the holes leading from them, and use instead movable toilet appurtenances.

It is well to have plenty of closet room for the storing of the various medicines and appliances necessary in case of sickness.

3. Ventilation.—The subject of ventilation has already been considered, but where there is sickness it becomes a question of vital importance, owing to the greater quantity of organic matter present in the air. A sick person needs two or three times as much air-space as one in good health. Although it is not possible to keep the air of a sick-room as pure as that outside, the aim should be to bring it as near that condition as possible.

In some cases, when the weather is cold or damp, open windows in the patient's room are inadvisable. In such cases the window in an adjoining room may be opened, and the air admitted from this room.

Especially at night great care must be exercised in the ventilation of the sick-room, as the outside air is apt to be cold, while the air inside needs to be renewed as much at night as during the day. Air which is too cold is an evil, but not so great a one as foul air.

A sick-room odor is an evidence of poor ventilation and should be rigidly guarded against.

When in cold weather the windows are opened, the patient should be well protected from draughts. The insertion of a board or wire screen below the lower sash, as described in the chapter on "VENTILATION," will usually accomplish this end.

4. The most important tests of disease are the pulse, temperature, and respiration.

1. **Pulse.**—In the chapter on "CIRCULATION" we learned about the heart. Each contraction of the heart sends out a wave which distends the blood-vessels, and which is carried on through the whole arterial system. This periodical distention is called the *pulse*. As this varies with the condition of the heart, it is a valuable index of its action.

The *pulse-beats* can be felt wherever an artery approaches the surface. It is usually most perceptible at the wrist and at the temples. To take a pulse accurately, place two or three fingers along the course of the artery, pressing it gently, and count the beats by tens for a minute. The average normal rate in an adult is seventy-two beats per minute; in a child, one hundred and twenty. When the pulse is rapid each beat occupies less than the usual time. An *intermittent pulse* is one in which the beat is now and then lost. An *irregular pulse* is one in which the succeeding beats differ in length, force, or character.

2. **Temperature.**—The second great aid in determining the condition of the patient is to take his temperature. The normal temperature ranges between 97½ and 99½ degrees, and any deviation from this indicates disease of some kind. A change in temperature is often the first symptom of disease, and may even occur before any indisposition is felt.

It is therefore of the greatest importance to understand the use of a clinical thermometer. This instrument is indispensable in every household. Before use, the index must be pushed down to several degrees below the normal mark. This may be done by holding it with the bulb down and shaking it until the mercury falls to the desired point.

The temperature is usually taken by placing the bulb of the thermometer under the tongue. The lips must be closed, but great care should be taken that the bulb of the thermometer be not bitten off. It may also be inserted in the armpit and at other places. The length of time required to take the temperature varies from three to ten minutes. Careful records should be kept of the time at which the temperature is taken and of the degree registered, from day to day.

3. **Respiration.**—The processes of circulation and respiration are so closely connected that whatever modifies the pulse affects the breathing. There are about four beats of the pulse to every respiration. A healthy adult breathes about eighteen times in a minute. With each inhalation he takes in twenty cubic inches of air. Respirations below eight or above forty per minute indicate some abnormal condition. Respirations, to be natural, must be counted without the consciousness of the patient.

To count accurately, lay the flat hand lightly over the stomach, where the motion may be distinctly felt.

5. The Administration of Medicine.—Medicines are administered in the form of pills, powders, or solutions. Medicines should be kept in a dry closet, as dampness impairs the activity of many drugs. The place should also be cool and dark, as heat and light cause decomposition. Only small quantities should be kept on hand, and these should always be of the best quality.

All bottles should be distinctly labeled both as to name or character of the medicine and as to the dose to be taken. The label should be carefully read every time before administering the medicine. Do not leave the bottles uncorked, shake them before giving the medicine, avoid defacing the label, and *never* give a medicine in the dark.

The spoon or glass in which the medicine is given should be washed immediately after use. To prevent disagreeable tastes, hold the nose while swallowing ; or before administering the medicine give some substance with a pungent flavor, as peppermint or wintergreen, which will weaken the sensibility of the nerves of taste. Licorice, dried orange, or a piece of bread may be used to remove disagreeable tastes.

6. Food.—In cases of sickness, the nature and quality of the food administered becomes a question of the greatest importance. Everything should be of the best, and should be well prepared and served.

Before taking food to the sick, it should be tasted to make sure that it is right. Too little food is usually better than too much; but a system of regularity in giving food is of great advantage. The aim should always be to give what will be easy to digest, and of value after it is digested.

When the patient is weak and helpless, the food should be given slowly and in small quantities, with sufficient intervals between the swallowings.

When there are symptoms of great thirst and it seems wise not to give too much water, small pieces of ice will prove both valuable and refreshing.

Forms of Food for the Sick.*

1. *Beef Tea No.* 1.—Take a pound of juicy beef cut from the round, remove all the fat, and cut the beef into very small pieces. Put it in an earthen pot and add a quart of cold water. Cover it closely, let it soak for an hour, and then simmer gently for two hours more, or till the strength is quite extracted from the beef. Strain and season with salt and pepper.

2. *Beef Tea No.* 2.—Mince finely a pound of lean, juicy beef, from which all the fat has been removed; put it into a wide-mouthed bottle or fruit-jar, just covering it with cold water, and cork it tightly. Set the jar into a kettle of

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* Taken chiefly from Miss Weeks's "Text-book on Nursing."

cold water over a slow fire, and let it boil for three hours. Strain and season with salt.

3. *Raw Beef Tea.*—To a half pound of raw beef, free from fat and finely minced, add ten grains of pepsin, and two drops of hydrochloric acid. Put this in a large tumbler, and cover with cold water. Let it stand for two hours at a temperature of ninety degrees, and stir frequently. Strain and serve ice-cold, in a red glass, if possible. Peptonized food does not keep well and should never be used more than twelve hours old.

4. *Chicken Broth.*—An old fowl will make a more nutritious broth than a young chicken. Skin, cut it up, and break the bones with a mallet. Cover well with cold water and boil slowly for three hours. Salt to taste. A little rice or tapioca may be boiled with it, if desired.

5. *Mutton Broth.*—Cut up fine two pounds of lean mutton, without fat or skin. Add a tablespoonful of barley, a quart of cold water, and a teaspoonful of salt. Let it boil slowly for two hours. If rice is used in place of the barley, it will not need to be put in till half an hour before the broth is done.

6. *Peptonized Milk.*—Stir up five grains of pancreatic extract, and fifteen of bicarbonate of soda in a gill of water ; mix thoroughly and add a pint of fresh milk. Put this in a bottle or a covered jug, and let it stand where it will keep warm for an hour. Then put on ice until required for use, or boil for two or three minutes to stop further digestive action. Milk so prepared will have a faintly bitter flavor ; it may be sweetened to taste, or used in gruels, etc., like ordinary milk.

7. *Flour Gruel.*—Mix a tablespoonful of flour with milk enough to make a smooth paste, and stir into a quart of boiling milk. Boil for half an hour, being careful not to let it burn. Salt and strain.

8. *Oatmeal Gruel.*—Boil a tablespoonful of oatmeal in a

pint of water for three quarters of an hour, then put it through a strainer. Season with salt.

9. *Cracker Gruel.*—Pour a pint of boiling milk over three tablespoonfuls of fine cracker crumbs. Butter crackers are best to use. Add half a teaspoonful of salt, boil up once all together, and serve immediately. Do not sweeten.

10. *Indian-meal Gruel.*—Mix a scant tablespoonful of Indian meal with a little cold water, and stir into a pint of boiling water. Boil for half an hour. Strain and season with salt. Sugar and cream may be added, if desired.

11. *Sago Milk.*—Wash a tablespoonful of pearl sago, and soak it over night in four of cold water. Put it in a double kettle, with a quart of milk, and boil till the sago is nearly dissolved. Sweeten to taste, and serve either hot or cold.

12. *Milk and Albumen.*—Put into a clean quart bottle a pint of milk, the whites of two eggs, and a small pinch of salt. Cork, and shake hard for five minutes.

13. *Egg Water.*—Stir the whites of two eggs into half a pint of ice-water, without beating; add enough salt or sugar to make it palatable.

14. *Egg Broth.*—Beat together one egg and a half a teaspoonful of sugar till very light, and pour on a pint of boiling water, stirring well to keep it from curdling. Add salt and serve hot.

15. *Hot Milk and Water.*—Boiling water and fresh milk in equal parts compose a drink highly recommended in cases of exhaustion, as it is quickly absorbed into the digestive system, with very little digestive effort.

16. *Lemonade with Egg.*—Beat one egg with two tablespoonfuls of sugar until very light, then stir in three tablespoonfuls of cold water, and the juice of a small lemon. Fill the glass with pounded ice, and drink through a straw.

17. *Toast Water.*—Toast three slices of stale bread to a very dark brown, but do not burn. Put into a pitcher and

pour over them a quart of boiling water. Cover closely and let it stand on ice until cold; then strain it.

18. *Apple Water.*—Slice into a pitcher half a dozen juicy sour apples. Add a tablespoonful of sugar, and pour over them a quart of boiling water. Cover closely and let it stand on ice until cold. Then strain.

19. *Barley Water.*—Wash two ounces of pearl barley in cold water. Then boil for three minutes and throw both waters away. Add two quarts of boiling water and boil till reduced to one quart—for about two hours—stirring frequently. Strain, add the juice of a lemon, and sweeten. For infants omit the lemon.

20. *Flax-seed Lemonade.*—Into a pint of hot water put two tablespoonfuls of sugar and three of whole flax-seed. Steep for an hour; then strain. Add the juice of a lemon, and set on ice until required.

21. *Bran Tea.*—To a pint of wheat bran add a quart of boiling water. Let it stand where it will keep hot, but not boil, for an hour. Strain and serve with sugar and cream.

22. *Corn Tea.*—Parch brown a cupful of dry, sweet corn, grind or pound it in a mortar. Pour over it two quarts of boiling water, and steep for a quarter of an hour.

23. *Crust Coffee.*—Take a pint of crusts—those of Indian bread are the best—brown them well in a quick oven, but do not let them burn; pour over them three pints of boiling water, and steep for ten minutes. Serve with cream.

24. *Rice Coffee.*—Parch and grind like coffee half a cupful of rice. Pour over it a quart of boiling water, and let it stand where it will keep hot for fifteen minutes; then strain and add boiled milk and sugar.

25. *Chocolate.*—Scrape fine an ounce of prepared chocolate. Add two tablespoonfuls of sugar and one tablespoonful of hot water; stir over a hot fire for a few minutes until it is smooth and perfectly dissolved; then pour into a pint of boiling milk, mix thoroughly, and serve at once. If

allowed to boil after the chocolate is added to the milk, it becomes oily and loses flavor.

26. *Cream of Rice.*—Boil the breast of a fowl and a cup of rice in broth of fowl until soft enough to rub through a fine sieve ; thin the paste thus formed with milk barely boiling ; season with salt and pepper, and nutmeg (if agreeable).

27. *Chicken Panada.*—Skin the chicken and cut it up into joints ; take all the meat from the bones ; cut small. Put this into a jar with a little salt, and set it into a saucepan of boiling water. Let it boil from four to six hours, then pass through a sieve and thin it with a little broth. Do not use the wings in the panada.

28. *Eggs.*—To prepare eggs for the sick, beat until very light, season to taste, and steam about two minutes.

29. *Arrowroot Jelly.*—To one cup boiling water add two heaping teaspoonfuls of best Bermuda arrowroot, one teaspoonful lemon-juice and two teaspoonfuls white sugar, if a sweetening is desired. Rub the arrowroot smooth in a little cold water ; then stir into the hot water, which should be boiling, with the sugar melted in it ; stir until clear, and add the lemon-juice. Wet a cup with cold water, and pour the jelly in to form. It can be eaten hot, and thinned with milk, if desired.

30. *Currant Drink.*—Pour one pint of water upon two tablespoonfuls of currant jelly, and stir until the jelly is dissolved. Drink when cold.

7. Bandaging.—The proper adjustment of bandages is a question of considerable importance in the treatment of wounds, etc. The bandage should be neither too loose nor too tight, as in the former case it is liable to slip, and in the latter the pressure may be painful or may impede the circulation.

Among other forms of bandages may be mentioned the *roller*, the *many-tailed*, and the *triangular* bandages

A *roller bandage* consists of a narrow strip of muslin, flannel, or other material, several yards long, evenly and tightly rolled together. (See Fig. 101.)

The advantage of this bandage is that it can be unwound as quickly as necessary, and thus the right smoothness and tightness may be secured.

In bandaging any *limb*, always begin at the extremity and work toward the center of the body from left to right. In finishing off a bandage, one or two straight turns should be made and the end folded under and pinned. Another good way to finish off is to split the last quarter of a yard through the middle, wind the ends around the part in opposite directions, and tie them.

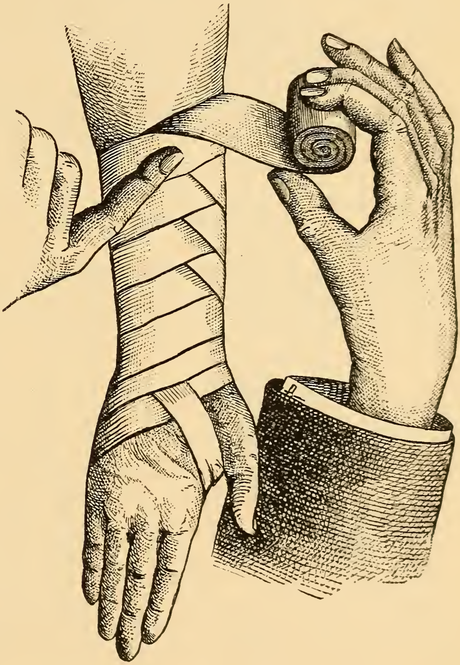

Fig. 101.

The Roller Bandage applied to the Arm.

In bandaging a *hand* with the roller bandage, begin at the tip of the first finger and roll the bandage around it to the base, then turn it around the wrist to keep it from slipping; then draw it up to the base of the second finger, wind up to the tip and back to the base; take another turn around the wrist, back to the root of the third finger, and so on until all the fingers are covered; then carry the bandage obliquely across the back of the hand, turn around the wrist, and carry it back to the further side; continue this until the back and palm of the hand are completely covered; finally cover the thumb by making alternate turns about it and the wrist, and finish off at the wrist as described above.

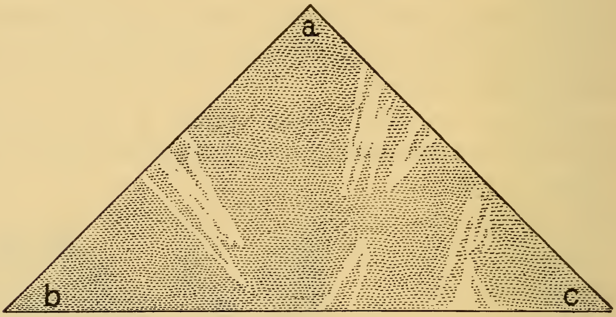

Fig. 102.

Triangular Bandage.

bc, lower border; *ab* and *ac*, side borders.

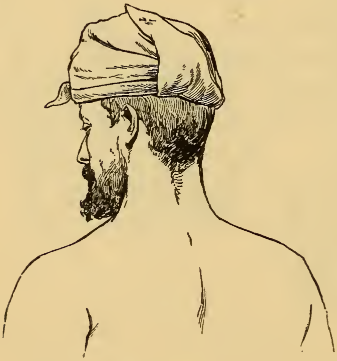

Fig. 103.

Triangular Bandage applied to the Head.

Bandages for the *foot* are made in a similar way, varying slightly to adapt them to the structure of the foot.

The *many tailed bandage* consists of a piece of muslin torn into strips from each side to within an inch or two of the center, which is left entire. It is used chiefly when the part to be covered must not be moved.

The *triangular bandage* is one of the most useful forms for the head. A piece of muslin is cut into a triangle, which has a lower border and two side borders, a point and two ends. (See Fig. 102.)

The lower border is laid across the forehead, while the point hangs over the neck. The two ends are carried back over the ears, crossed behind, brought forward, and tied in front of the forehead. The point is then turned upwards and fastened with a pin above. (See Fig. 103.)

Esmarch Bandages.—The Esmarch bandages are made of rubber, and are used to reduce swelling. Special care must be exercised not to make a rubber bandage too tight. The Esmarch bandages are especially adapted to the extremities of the body.

Plaster of Paris Bandages.—For fractures, dislocations, curvatures, etc., it is usually necessary to supply a strong support. For this purpose the plaster of Paris bandage is very useful. These bandages can be bought ready prepared for use. They are applied while moist and pliable, and are adjusted to the injured part like the ordinary roller bandage. When the plaster dries, it hardens and forms a strong support.

Lighter bandages may be made on the same plan of starch-paste, silicate, paste-board, or *gutta-percha*.

8. Poultices.—Poultices serve as convenient means of applying warmth and moisture. They are usually applied to prevent or check inflammation, and they tend to relieve the pain, and to prevent the formation of pus. They may be made of various materials. One form consists of several thicknesses of lint or soft cloth wrung out in hot water.

Linseed poultices are often very efficacious. The meal should be poured gradually into boiling water and stirred until it is free from lumps and just thick enough to be cut with a knife. The poultice must be smoothly spread upon a piece of muslin and covered with some thin material.

Bread poultices are made by pouring boiling water over soft bread, until it is of a consistency to admit of being spread smoothly. These poultices are lighter than those made of linseed, but they cool more quickly.

Mustard poultices are made by adding mustard to the ordinary linseed poultice.

Other poultices are made of starch, hops, bran, etc.

9. Baths.—Bathing is at all times a matter of great importance for the maintenance of health ; but in sickness it becomes even more necessary, as the exhalations from various diseases are dangerous, and cleanliness is a positive aid to recovery.

If care is exercised, no harm will occur, as a general rule, from the bathing. A feeble patient should be wrapped in a sheet and lowered gently into the water. A warm, dry sheet should be kept ready for use when the patient leaves the bath.

Baths are composed almost exclusively of water, to which medicaments are occasionally applied. They are either *hot*, *tepid*, or *cold*.

The temperature of the bath-room should be carefully regulated, and the duration of the bath must be considered. Cold and hot baths should not usually be continued more than five minutes, and tepid baths not more than from a quarter to half an hour.

Cold baths are employed to produce reaction, refrigeration, or nervous shock. Hot baths, to induce perspiration, soothe pain, or relax spasms.

There are special forms of baths adapted to special parts of the body ; as, *foot-baths*, *hip-baths*, *arm-baths*, and *hand-baths*.

There are many other kinds of baths, of a special nature, prescribed by physicians. Among these may be mentioned : *salt baths*, *moor baths*, *ferruginous baths*, *alum baths*, *sulphur baths*, *aromatic baths*, *pine-needle baths*, *malt baths*, and *vapor baths*.

QUESTIONS.—1. On what does the recovery of a patient greatly depend? What are the duties of a nurse toward the patient? Toward the physician? Toward himself?

2. Why is it necessary that a room be set aside especially for the sick? In what part of the house should it be? How furnished?

3. Why is ventilation especially important in a sick-room? How may it best be regulated? What precautions must be taken at night?

4. What are the tests of disease? What is meant by pulse? Where may pulse beats be best felt? What is an intermittent pulse? An irregular pulse? What is the normal temperature of the body? Describe the use of the clinical thermometer. How are the pulse and respiration related? How may respirations be counted?

5. Give some general rules for the administration of medicines. Where and how should the medicine bottles be kept? What care must be exercised in regard to spoons and glasses used?

6. Why is the character of the food taken of great importance with a patient? What care should be exercised in the selection and administration? Describe some forms of food suitable for the sick.

7. Name some of the ordinary forms of bandages. Of what material are they made? Describe the roller bandage. The many-tailed bandage. The triangular bandage. How would you bandage a limb? A hand? The head? Describe the Esmarch bandage. The plaster of Paris bandage.

8. What are poultices? For what are they designed? Name several kinds. Describe the linseed poultice. The bread poultice. The mustard poultice.

9. Why are baths even of greater importance in sickness than in health? What is the use of the hot bath? Of the cold bath? Name some special kinds of baths.

INDEX.

INDEX.

A

Abdomen, 17, 19, 87.
Abductor minimi digiti, 56.
Absorption, intestinal, 94.
Acetic fermentation, 77.
Achilles, tendon of, 49.
Acids, 106.
Aconite, 106.
Action of heart, 117.
Adam's apple, 197.
Adipose tissue. 20.
Administration of medicine, 235.
Adulteration, 79.
Ague, 213.
Air, 133, 201.
Air-cells, 136.
Albumen, 71, 73.
Albuminoids, 73, 90.
Alcohol, 69, 75, 78, 104, 106.
    effect on blood, 130.
    effect on circulation, 130.
    effect on digestion, 104.
    effect on lungs, 146.
    effect on mind, 170.
    effect on muscular tissues. 146.
    effect on nerves, 169.
    effect on respiration, 146.
    effect on sense of taste, 182.
    effect on will, 170.
    moderate use of, 172.
Alcoholic appetite, 170, 171.
Alcoholic drinks, 42, 55, 68, 77, 79, 102.
Alcoholic phthisis, 146.
Alimentary canal, 81.
Alum baths, 244.
Ambulance service, 221, 222.
Anæsthetics, 167.
Anatomy, 17, 20.
Animal foods, 75.
Animal impurities in water, 213.
Animals, 18, 72.
Ankle, 33, 34.
Annular ligament, 40.
Annular muscles, 88.
Antidotes, 99, 106.
Anvil, 192.
Aorta, 111, 118, 119.
Apoplexy, 221, 225.
Apparatus, digestive. 19.
Appetite, 100.
Apple water, 239.
Aqueous humor, 186.
Arbor vitæ, 158.
Arm, 31, 34.
Arm baths, 244.
Aromatic baths, 244.
Arrowroot jelly, 240.
Arsenic, 106.
Arteries, 111, 121, 125, 126. 142.
    injuries to, 129.
Articulation, 197. 199.
Artificial respiration, 222. 227.

Artificial ventilation, 204, 205.
Asphyxia, 221, 227.
Assimilation, 126.
Atlas, 28.
Auricles, 111, 114.
Axis, 28.

B

Ball-and-socket joints, 39.
Bandages, 38, 240.
Barley water, 239.
Bathing, 67, 244.
Beef-tea, 236.
Belladonna, 106.
Biceps, 45, 47, 49.
Biceps flexor cruris, 56.
Biceps flexor cubitis, 56.
Bicuspid teeth, 84.
Bile, 92, 93.
  secretion of, 102.
Bladder, 97.
Bleeding, arrest of, 223.
Blind spot of eye, 188.
Blisters, 60.
Blood, 102, 111.
  changes in, 142.
  coagulation of, 74, 113.
  composition of, 112, 113.
  corpuscles, 112.
Blood, course of, 123.
  gains and losses in, 127.
  uses of oxygen in, 142.
Blood-vessels of kidneys, 96.
Bodies, 17.
Body, divisions of, 19.
  life of, 71.
  organs of, 149.
  temperature of, 65, 143.
Bones, 18, 19, 20, 23, 44.
  as fertilizers, 35.
Bones, carpal, 33.
  frontal, 24.
  hygiene of, 41.
  ingredients of, 34.
  injuries to, 38.
  metacarpal, 33.
  number of, 24.
  occipital, 24.
  of chest, 29.
  of joints, 40.
  of lower extremities, 33.
  of upper extremities, 31.
  parietal, 24.
  structure of, 35–38.
  table of, 44.
  tarsal, 33.
  temporal, 24.
Bony structure, changes of, 37.
Bony tissue, 20.
Brachialis, 56.
Brain, 25, 153.
  a double organ, 155.
  convolutions of, 156.
  exercise of, 168.
  weights of, 154.
Bran tea, 239.
Bread poultices, 243.
Breathing, fullness of, 145.
  process of, 135.
Broiling, 100.
Bronchi, 133, 136.
Bronchial tubes, 136.
Bruises, 223.
Burns and scalds, 68, 225.

C

Canals, 37.
Capacity of lungs, 141.
Capillaries, 59, 114, 121, 128.
  of kidneys, 96.

Capillaries of lungs, 122, 137.
Capsular ligament, 40.
Carbon, 71.
Carbonic acid gas, 76, 134.
Cardiac orifice, 88.
Care of the sick, 231–245.
Carpal bones, 33, 44.
Cartilage, 17, 25, 27, 37, 39.
Cartilaginous tissue, 20.
Casein, 71, 73, 74.
Cautery, 227.
Cells, 19, 37.
Cerebellum, 149, 156, 157, 158.
Cerebro-spinal nervous system, 153, 162.
Cerebrum, 149, 156, 157, 158.
Cervical vertebræ, 44.
Changes of bony structure, 37.
Charcoal filter, 214.
Chemical change of food, 73.
Chest, 19, 87.
  bones of, 26, 29, 44.
  muscles of, 51.
Chicken broth, 237.
Chicken panada, 240.
Chimney as ventilator, 204.
Chloral hydrate, 173.
Chloroform, 167, 173.
Chocolate, 239.
Choking, 225.
Cholera, 214.
Choroid coat, 185.
Chyle, 81, 93.
Chyme, 81, 90.
Cilia, 133, 137.
Circulation, 111–132.
  general plan of, 111.
  hygiene of, 128.
Circulatory system, 19.
Clavicle, 23, 31, 44.
Cleanliness, 67.
Cleanliness of the teeth, 101.
Clinical thermometer, use of, 234.
Clot, 113.
Clothing, 66.
Coagulation, 74, 113.
Coccyx, 44.
Cochlea, 175, 192.
Cold baths, 244.
Colds, 67.
Cold sweats, 105.
Collar bone, 31.
Colon, 90, 96.
Colored blood corpuscles, 112.
Colorless blood corpuscles, 112.
Combustion of blood, 143.
Common arsenic, 106.
Common sensation, 175.
Complexion, 61.
Composition of air, 201.
  of blood, 112, 113.
Compound joints, 39.
Concha, 175, 191.
Condiments, 102.
Conscious action, 162, 164.
Contagious diseases, 65.
Contraction, 52.
Contusions, 223.
Convolutions, 149, 156.
Cooking, 75.
Cords, 197.
  vibrations of, 199.
Corn, 59, 60.
Cornea, 175, 185, 186.
Corn tea, 239.
Corpuscles, 23, 37, 112.
Course of blood, 123.
Cracker gruel, 238.
Cranial nerves, 158, 163.
Cranium, 149.
Cream of rice, 240.
Crown of tooth, 82.

Crust coffee, 239.
Crystalline lens, 186, 189.
Currant drink, 240.
Curvature of spine, 29.
Cuspid teeth, 83, 84.
Cuticle, 59, 60.
Cutis, 59, 60, 62, 177.
  blood-vessels of, 62.
  nerves of, 62.

D

Deafness, 194.
Deep-well waters, 211, 212.
Deformities, 29.
Deltoides, 56.
Dentine, 81, 83, 84.
Diaphragm, 45, 51, 87.
Diet, nature of, 99.
Difference between animals and plants, 18.
Digestion, 81–98.
  hygiene of, 99–108.
Digestive apparatus, 19.
Digitalis, 106.
Diseases, contagious, 65.
Diseases of kidneys, 102.
Dislocations, 41, 223.
Distillation, 77.
Dorsal region, 29.
Dorsal vertebræ, 44.
Drainage, 217.
Drains, 218, 219.
Draughts, 203.
Drowning, 227.
Ducts, 59, 64.
Duodenum, 92.
Dwellings, 217–219.
Dysentery, 214.
Dyspepsia, 99, 101, 213.

E

Ear, 18, 177, 190.
  bones of, 44.
  hygiene of, 194.
Eating, manner of, 99.
  times of, 100.
Egg broth, 238.
Eggs, 240.
Egg water, 238.
Emergencies and accidents, 221–230.
Enamel, 83, 84.
Enteric fever, 214.
Epiglottis, 87, 140, 198.
Epilepsy, 167, 169.
Erysipelas, 211.
Esmarch bandages, 243.
Esophagus, 81, 82, 86, 87.
Ether, 173.
Ethmoid bone, 44.
Etymology of terms, 17, 23, 45, 59, 71, 81, 99, 111. 133, 149, 167, 175, 197, 201, 211, 217, 221, 231.
Eustachian tube, 87, 192, 194.
Evaporation, 65.
Excretion, 81.
  organs of, 59, 96.
Exercise, 41, 52, 128.
  of brain, 168.
  of nervous system, 168.
Exhaustion from heat, 222.
Exit tubes of kidneys, 96.
Expiration, 135, 228, 229.
Extensors, 45, 51.
Extensor carpi radialis, 56.
Extensor carpi ulnaris, 56.
Extensor digitorum, 56.
Extensor pollicis, 56.
Exterior muscles, 56.

External auditory canal, 191.
Extremities, 19.
Eyeballs, 184.
Eyelids, 184.
Eyes, 18, 177, 183.
  hygiene of, 190.
Eye sockets, 26.

F

Face, 19.
  bones of, 24, 26, 44.
Fainting, 105, 129, 222, 225.
False ribs, 30, 44.
Fanning, 222.
Far-sightedness, 189.
Fatty degeneration of tissues, 55.
Fats, 73, 74.
Femur, 33, 36, 44.
Fermentation, 71, 76, 77.
Ferruginous baths, 244.
Fibrin, 73.
  of blood, 112.
Fibula, 23, 33, 44.
Filters, 103, 214, 215.
Finger, nerves of, 178.
Flax-seed lemonade, 239.
Flesh, 18.
Flexors, 45, 51.
Flexor digitorum, 56.
Floating ribs, 30, 44.
Flour gruel, 237.
Flues, 207.
Food, 41, 71–80, 100.
  amount of, 100.
  digestion of, 93.
  distribution of, 74.
  diversity of, 74.
  for the sick, 236, 240.
Foot, 34.
Foot-baths, 244.
Fore-arm, 31, 34.
Foreign bodies, 226.
Foul-air registers, 206, 207, 208.
Fowler's solution, 106.
Fractures, 38, 40, 223.
Fresh air, effect of, 129.
Fresh-air registers, 207, 209.
Frontal bone, 24, 44.
Frost-bite, 225.

G

Gall bladder, 92.
Ganglia, 149, 161.
Gastric juice, 89.
Gastrocnemius, 56.
General structure of bone, 35.
Glands, 59, 63, 64, 65, 85.
Glottis, 197, 198, 199.
Glutæus maximus, 56.
Glutæus medius, 56.
Gluten, 73.
Gray matter, 149, 150, 156.
Great fissure of brain, 155.
Gullet, 82.

H

Habits, 164, 170.
Hair, 61.
Hair sacs, 63.
Hammer, 192.
Hand, 31.
  structure of, 54.
Hand-baths, 244.
Hard water, 213.
Head, 19, 24.
  muscles of, 56.
Headache, 213.
Health of body, 99.
Hearing, 177, 190.

Heart, 20, 118, 142.
  action of, 117.
  beats, 118.
  burn, 101.
  muscles of, 51.
  passages of, 115.
Heel, 49.
Hemlock, 106.
Hemorrhage, 111, 113, 225.
Hepatic artery, 125.
Hepatic vein, 124, 125.
Heredity, 167, 171.
Hinge joint, 32, 39.
Hip-baths, 244.
Hip-bones, 31.
Hip-joint, 33.
Hob-nailed liver, 102.
Homogeneous substances, 72.
Hot baths, 244.
Hot milk and water, 238.
Human body, weight of, 19.
Humerus, 32, 44.
Humors, 186.
Hunger, 72.
Hydrogen, 71.
Hygiene, 17, 20.
Hygiene of bones, 41.
  of circulation, 128.
  of digestion, 99–108.
  of ears, 194.
Hygiene of eyes, 190.
  of muscular system, 52.
  of nervous system, 167–174.
  of respiration, 143.
  of the skin, 65.
Hyoid bone, 26, 44, 197.

I

Images, 187, 188.
Impure water, 103, 212.
Incisors, 83, 84.
Inferior maxillary bone, 44.
Indian-meal gruel, 238.
Individuals, 18.
Induration, 102, 104.
Inhibitory nerves, 130.
Injuries to bones, 38.
Inner ear, 190, 192.
Innominata, 44.
Inorganic substances, 72, 73.
Insanity, 167, 171.
Insensible perspiration, 65.
Inspiration, 135, 228, 229.
Instep, 34.
Intercostal muscles, 51, 138, 139.
Interdependence of parts of body, 55.
Intermittent pulse, 234.
Intestinal absorption, 94.
  juices, 91.
Intestines, 81, 82, 90.
Intoxication, 227.
Introduction, 17–21.
Involuntary muscles, 162.
Iris, 175, 185.
Iron in water, 213.
Irregular pulse, 234.

J

Jaws, 26.
Joints, 20, 38, 39.
  bones of, 40.
  injuries to, 40, 41.

K

Kidneys, 82, 96.
  diseases of, 102.
Knee-pan, 33.

L

Lachrymal bones, 26, 44.
Lachrymal glands, 184.
Lacing, evils of, 145.
Lacteals, 94, 95, 128.
Lake water, 211, 212.
Large intestine, 90.
Larynx, 133, 135, 140, 197, 198.
Latissimus dorsi, 56.
Laudanum, 173.
Lead-poisoning, 213.
Leather, 62.
Left auricle, 115.
Left ventricle, 115.
Leg, 34.
Leguminous plants, 74.
Lemonade with egg, 238.
Ligaments, 39, 40, 49.
Light, 186.
Linseed poultices, 243.
Liver, 82, 92, 102.
  effect of alcohol on, 102.
Living bodies, 17, 18.
Lockjaw, 55, 105, 224.
Loudness of voice, 199.
Lower extremities, 24, 30.
  bones of, 33.
  muscles of, 56.
Lower vena cava, 126.
Lumbar region, 29.
Lumbar vertebræ, 44.
Lungs, 18, 96, 137.
  capacity of, 141.
  function of, 141.
Lymphatics, 128.

M

Malar bones, 26, 44.
Malt baths, 244.
Mania, 167.
Many-tailed bandage, 240, 242.
Marshall Hall's ready method in asphyxia, 227.
Masseter, 56.
Mastication, 82, 86.
Mechanical ventilation, 204.
Medicine, administration of, 235.
Medulla oblongata, 149, 156, 157, 158.
Membranes, 17, 20, 39.
Mental states, 167.
Mercury, 106.
Mesenteric glands, 95.
Mesentery, 81, 94, 95.
Metacarpal bones, 23, 33, 44.
Metatarsal bones, 23, 34, 44.
Middle ear, 190, 191.
Milk and albumen, 238.
Mineral food, 73.
Minerals, 72.
Minute structure of bone, 37.
Mitral valve, 117, 126.
Moderate use of alcohol, 172.
Molar teeth, 83, 84.
Moor baths, 244.
Morphine, 167, 173.
Motor fibers, 160.
Mouth, 177.
Movement of animals, 18.
  of plants, 18.
Mucous membrane, 82.
  of nose, 182.
Muriatic acid, 106.
Muscles, 20, 45–58.
  annular, 88.
  arrangement of, 51.
  classes of, 46.
  forms of, 45.
  intercostal, 51.
  involuntary, 46, 47.

Muscles, names of, 56.
  of the chest, 51.
  of the eye.
  structure of, 47.
  table of, 56.
  uses of, 56.
  voluntary, 46, 47.
Muscular sense, 52.
Muscular system, hygiene of, 52.
Muscular tissue, 20.
Mustard poultices, 244.
Mutton broth, 237.

N

Nails, 61.
Names of muscles, 56.
Narcotic appetite, 170.
Narcotic poisons, 106.
Nasal bones, 26, 44.
Nasal openings, 87, 135.
Nausea, 99, 101, 105.
Near-sightedness, 189.
Neck, 19.
  muscles of, 56.
Neck of tooth, 82.
Nerve centers, 150, 161.
  fibers, 150, 160, 161.
Nerves, 20, 153.
  cranial, 158.
  pneumogastric, 158.
Nervous impulses, 162.
Nervous matter, arrangement of, 150.
Nervous system, 19, 149–166.
  compared to telegraph system, 160.
  divisions of, 153.
  exercise of, 168.
  hygiene of, 167–174.
Nervous system, rest of, 168.
Nervous tissue, 20.
  nature of, 149.
Nitric acid, 106.
Nitrogen, 71, 133.
Non-living bodies, 17.
Nose, 177.
Nourishment, 53, 99.
  demand for, 128.
Nucleus, 45.
  of muscular fibers, 47.
Nursing, 231.
Nutrition, 81.
Nux vomica, 106.

O

Oatmeal gruel, 237.
Oblique muscle, 56.
Occipital bone, 23, 24, 44.
Occipito-frontalis, 56.
Olfactory nerves, 183.
Opium, 105, 106, 173.
Optic nerves, 186.
Orbicular bone, 192.
Orbicularis palpebrarum, 56.
Orbits, 184.
Organic substances, 72.
Organogens, 71.
Organs, 18, 149.
  of circulation, 114.
  of respiration, 135.
Ossicles, 175, 192.
Outer ear, 190.
Oxygen, 71, 133.

P

Pain, 176.
Palate, 44.

Pancreas, 81, 82, 92.
Pancreatic juice, 92, 93.
Papillæ of skin, 63.
  of tongue, 181.
Paralysis, 163, 169.
Paregoric, 167, 173.
Parietal bone, 23, 24, 44.
Paris green, 106.
Parotid glands, 85.
Passages of the heart, 115.
Patella, 23, 33, 44.
Pectoral muscle, 56.
Pelvis, 29, 30, 31, 33.
  bones of, 26, 44.
Pepsin, 81, 89.
Peptonized milk, 237.
Pericardium, 111, 114.
Periosteum, 23, 36, 38, 49.
Permanent teeth, 83, 84.
Peronæus longus, 56.
Perspiration, 64, 85.
Perspiratory ducts, 64.
Perspiratory glands, 64, 65, 85.
Petrous bone, 190.
Phalanges, 23, 33, 34, 44, 61.
Pharynx, 82, 86, 197.
Phthisis, 133.
Physiology, 17, 20.
Pills, 235.
Pine-needle baths, 244.
Pivot joints, 39.
Plants, 18, 72.
Plasma, 112, 113.
Plaster of Paris bandages, 243.
Platysma myoides, 56.
Pleura, 133, 138.
Plumbing, 218.
Pneumogastric nerve, 158.
Poisoning, 227.
Poisons, 105, 106.
Pores, 59.
Portal circulation, 125.
Portal vein, 124, 125.
Position, 145.
Poultices, 243.
Powders, 235.
Pulmonary artery, 116, 118, 119.
Pulmonary circulation, 125.
Pulmonary consumption, 145.
Pulmonary vein, 122.
Pulse, 118.
Pulse-beats, 234.
Punctured wounds, 224.
Pupil of eye, 185.
Pure air, necessity for, 221.
Purification of water, 214.
Purity of water, 103.
Pylorus, 88, 90.

Q

Quality of voice, 199.

R

Radius, 32, 33, 44.
Rain water, 211, 212.
Raw beef-tea, 237.
Reading, 200.
Rectus abdominis, 56.
Reflex action, 164.
Refuse, 217, 218.
Relaxation, 52.
Removal of waste matter, 218.
Respiration, 133–148, 235.
  hygiene of, 143.
  organs of, 135.

Respiratory organs, 19.
Rest, 52.
Retina, 175, 186.
Reversed images, 187.
Review of the bones, 44.
Ribs, 29.
Rice coffee, 239.
Rickets, 42.
Right auricle, 115.
Right ventricle, 115.
Ring muscles, 88.
River water, 211, 212.
Roasting, 100.
Roller bandage, 240, 241.
Root of nerve, 160.
Root of tooth, 82.
Rubber bandages, 243.

S

Sacrum, 31, 44.
Sacs, 59.
Sago milk, 238.
Saliva, 85.
Salivary glands, 85, 181.
Salt baths, 244.
Salts, table of, 72.
  iron, 72.
  lime, 72.
Sanitary conditions of dwellings, 217.
Scalds, 68, 225.
Scapula, 32, 44.
Sclerotic coat, 185.
Sebaceous glands, 63, 184.
Semi-circular canals, 192.
Semilunar valves, 117, 126.
Sense of touch, 59.
Senses, 175–196.
Sensible perspiration, 64.
Sensor fibers, 160, 163.
Serratus magni, 56.
Serum, 113.
Sewage, 218.
Shallow-well waters, 211, 212.
Shin-bone, 33.
Shoulder, 31.
Shoulder-blade, 32.
Shoulder-joint, 32.
Sick-room, 232.
Sight, 177, 183, 185.
Sinews, 48.
Singing, 200.
Site, 217.
Skeleton, 23.
  uses of, 24.
Skin, 20, 59–70, 96, 177, 179.
  colored cells of, 60.
  hygiene of, 65.
  structure of, 59.
Skull, 19, 24.
Skull bones, 25, 44.
Sleep, 168.
Small intestine, 90.
Smell, 177, 182, 183.
Smoker's heart, 131.
Snake bites, 226.
Soft palate, 87.
Soleus, 56.
Solutions, 235.
Sound, 194, 199.
Sources of water, 211.
Special senses, 175–196.
Sphenoid bone, 44.
Spinal canal, 27.
Spinal column, 26, 28, 29.
  bones of, 26.
Spinal cord, 25, 27, 159.
Spinal nerves, 159.

Spine, bones of, 44.
Sprains, 40, 223.
Spring water, 211, 212.
Starch, 85.
Starvation, 225.
Stationary wash-stands, 233.
Sterno-cleido-mastoideus, 56.
Sternum, 29, 30, 44.
Stimulants, 102.
Stirrup, 192.
Stomach, 82, 87.
  muscles of, 51.
Stored rain water, 212.
Strangulation, 227.
Stretchers, 222.
Structural arrangement of houses, 218.
Structure of hand, 54.
  of skin, 59.
Strychnine, 106, 107.
Sublingual glands, 85.
Sub-maxillary glands, 85.
Suffocation, 222, 227.
Sugars, 73, 74, 85.
Sugar of lead, 106.
Sulphur baths, 244.
Sulphuric acid, 106.
Sun dew, 19.
Sunlight, effect of, 129.
Sunstroke, 222.
Superior maxillary bone, 44.
Supinator, 56.
Support, 18.
Surface water, 211, 212.
Sutures, 23, 25.
Sweet bread, 93.
Sympathetic nervous system, 153, 161.
Synovial membrane, 39, 42.
Systemic capillaries, 126.
Systemic circulation, 125.

T

Table of bones, 44.
Tarsal bones, 33, 34, 44.
Taste, 177, 180–182.
Teeth, 24, 82.
  cleanliness of, 101.
  decay of, 85.
  permanent, 83.
  temporary, 83.
Temperature, 234.
  of air, 202, 203.
  of body, 65, 143.
Temporal bone, 24, 44.
Temporal muscle, 56.
Temporary teeth, 83.
Tendons, 45, 48, 50.
Tendon of Achilles, 49.
Tensor femoris, 56.
Tepid baths, 244.
Terms, etymology of, 17, 23, 45, 59, 71, 81, 99, 111, 133, 149, 167, 175, 197, 201, 211, 217, 221, 231.
Thigh, 34.
Thigh-bone, 33.
Thirst, 72.
Thoracic duct, 95.
Tibia, 33, 44.
Tibialis anticus, 56.
Times of eating, 100.
Tinctures, 76.
Tissues, 20.
  waste and repair of, 71.
Toast water, 238.
Tobacco, 42, 55, 105, 106.
  effect on heart, 131.
  effect on nervous system, 172.
  effect on sense of taste, 182.
Tone, 199.
Tongue, 86, 181.

Toothache, 85.
Touch, 59, 177.
  education of, 179, 180.
Tourniquet, 224.
Trachea, 133, 135, 136, 140, 197.
Trapezius, 56.
Triangular bandage, 240, 242.
Triceps, 56.
Tricuspid valves, 116, 126.
True ribs, 30, 44.
Trunk, 19, 24, 87.
  bones of, 26.
  muscles of, 56.
Tuber, 71.
Turbinated bone, 44.
Tympanum, 175, 191.
  external membrane of, 192.

U

Ulna, 32, 33, 44.
Unconsciousness, 221.
Upland surface water, 212.
Upper extremities, 24.
  bones of, 31.
  muscles of, 56.
Upper vena cava, 126.
Urea, 92.
Uses of muscles, 56.

V

Valves of heart, 115, 116.
Vapor baths, 244.
Vastus externus, 56.
Vegetable foods, 75.
Vegetable impurities in water, 213.
Veins, 114, 122, 124, 126.
Venæ cavæ, 122, 123, 124, 126.
Venomous bites, 226.
Ventilation, 144, 201–209.
  artificial, 204, 205.
  mechanical, 204.
  of sick-rooms, 233.
Ventricles, 111, 114, 115.
Venus' flytrap, 19.
Vertebræ, 23, 26, 27, 28, 36.
Vestibule, 192.
Villi, 91.
Vinegar, 77.
Vinous fermentation, 77.
Vitreous humor, 186.
Vocal cords, 198.
Voice, 197–200.
  loudness of, 199.
  quality of, 199.
  volume of, 199.
Vomer bone, 44.
Vomiting, 105.

W

Wash-stands, 233.
Waste and repair, 71.
Waste of tissue and energy, 167.
Water, 72, 73, 103.
  sources of, 211.
Water filters, 214, 215.
Water in relation to health, 211–216.
Watery vapor, 134.
Weights of brains, 154.
Well water, 211.
White arsenic, 106.
White lead, 106.
White matter, 149, 150, 156, 160.
Windpipe, 87.
Wounds, 223.
Wrist, 34.

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